Second Edition

Introduction to Social Forestry

M Sitaram Rao

INTRODUCTION TO SOCIAL FORESTRY

Second Edition

M. SITARAM RAO, I.F.S.

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PREFACE TO THE SECOND EDITION

In recent times severe droughts and extensive floods have made people aware of the importance of forests and tree cover. Keeping in mind the recent developments, this second edition brings out the causes for the destruction of forests and the concomitant diseases that are likely to spread.

Water, which is a primary need for sustenance of mankind, needs indepth management and this aspect has been covered in a separate chapter.

New trends and developments in raising of Eucalyptus plantations and a revolutionary method of the management of bamboo clumps have been discussed in detail.

With the call of the Prime Minister of India for development of wastelands and protection of forests, this second edition will go a long way in acquainting one and all to the role of Social Forestry.

I trust that this edition will be useful in helping to create a tree cover to mitigate the miseries due to drought and floods.

M. SITARAM RAO

FOREWORD

Forests and Forestry were subjects of a Department in the Government, geared mostly towards conservation and exploitation.

It is only in the recent past that the forest influences on the climate and agricultural production have come to fore.

Farm Forestry as an Elective is being introduced in the Agricultural Universities and the subject might get encouragement in the other general Universities as well.

Moreover, the functions and beneficial effects of the vegetation cover is not well appreciated by many and several are ignorant of the role played by the forests in maintaining equilibrium in the climate of a locality.

The present book "Introduction to Social Forestry" by Sri M. Sitaram Rao, is not only a likely syllabus for an Elective Course to the undergraduates in the Agricultural Universities, but it also introduces administrators, managers, development officers and extension workers to the subject of Social Forestry.

The book fulfils a long felt need for such introduction.

A.P. Agricultural University
Hyderabad

DR. MIR HAMID ALI
Dean of Agriculture

PREFACE TO THE FIRST EDITION

The National Commission on Agriculture in Part IX of its Report has recommended, introduction of Forestry in the Agricultural Universities of the country. In compliance to these recommendations, several Agricultural Universities have opened a Department of Forestry to organise research, teaching and extension of Farm Forestry through the Universities.

At present, Farm Forestry as a new subject has been introduced as an Elective Course, at the undergraduate level. The book could be used as a text for the elective course offered by the various Agricultural Universities. In future, possibly, the subject will be widened to award higher degrees in Forestry.

Forestry is a very vast subject with possibilities of several combinations. To acquaint the students at the undergraduate level no comprehensive and concise literature, which introduces Forestry and its application for better agriculture, is available in the country.

The book attempts to acquaint the students of Agricultural Universities and others to understand the subject of Forestry at a glance. Chapters 1 to 7 serve as an introduction to Forestry and a few aspects of Social Forestry. Chapter 8 deals with various techniques to raise forest species and Chapter 9 gives an account of some important species for persons involved in Vanamahotsava and such other programmes.

I am grateful to Sri C.V. Konda Reddy, I.F.S., Additional Chief Conservator of Forests, Andhra Pradesh, for going through the manuscript and suggesting improvements.

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I am indebted to Sri K.V. Rajan, who took all the pain to type the manuscript.

Hyderabad

M. SITARAM RAO

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In compiling the information for this book, I have consulted the lecture notes of Sri Y.M.L. Sharma, I.F.S. (Retd.), Chief Conservator of Forests, Karnataka, which he had drafted as Visiting Professor for Farm Forestry, in the University of Agricultural Sciences, Bangalore.

The other publications which were consulted are: *Forest Ecology* by G.S. Puri, *Forest Types* by H.G. Champion and S.K. Seth, and *Symposium Publications of the Forest Department of Haryana*.

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The forest is a peculiar organism of unlimited kindness and benevolence that makes no demands for its sustenance and extends generously the products of its life activity; it affords protection to all beings, offering shade even to the axeman who destroys it.

Gautama Buddha

Trees are useful to man in two distinct ways: as producers of a wide variety of goods commonly called 'forest produce', and as custodians of favourable environmental conditions. It would not make sense to try to qualify one of these functions as more important than the other. Both are indisputably essential to the well being, indeed to the survival of man.

Gunnar Poulsen

CHAPTER 1

INTRODUCTION

History of Forest Development

With the creation of the Universe, first there was water then slowly land developed. With land and earth coming up, the first to appear were trees and vegetation. With the advent of civilisation and the realisation of the knowledge of cultivation, forests were cleared and agriculture commenced. Thus, slowly the forests disappeared.

The first casualty of successive invasions of India were the forests. However, the notes left by visitors and travellers to the country give a lucid description of the extent of forests and the wild life therein. Fa Hien and Heun Tsang, described forests in districts that are now drought prone, where elephants used to roam.

During the invasion of Alexander the Great (327 B.C.) the formidable stretches of forests he had to cross saved many of the southern states of our country from his attacks.

However, by the time of Ashoka's reign, we find that heavy destruction had already occurred, particularly in the Gangetic Plains. He, therefore, issued an edict to plant trees along the roads to shelter passersby.

Heavy destruction of forests occurred in the latter part of the eighteenth and early part of the nineteenth century due to the foreigners carrying away much of the produce to their countries. Much of the majestic teak was felled for purposes of building battle-ships. There was no control over the felling and removal of forest wealth.

A conservator of forests was appointed by the government only in 1847 to manage the forests.

In 1864 Dr. Brandis, a German, was appointed to formulate scientific methods to manage the forests. On his recommendation the first Forest Act came into being in 1865. A commission was formed to recommend a forest policy in 1880.

During 1878, the first Forest School was started and in 1912 the Madras Forest College was established.

During 1894, the first national policy to manage forests was enunciated, which laid down sound principles of preservation of forests, and creation of reserved forests and protected forests and in 1910 a Board of Forestry was constituted. In 1921, the forests became a state subject. By this time, much of the forests were already destroyed in the First World War of 1914-18, for fuel and timber. During the Second World War of 1939-45, forests were further denuded to meet the war requirements. In this period charcoal production was increased for supply to run army trucks. After the Second World War, forest-based industries cropped up in numbers and forests were affected with exploitation continuing unabated. In the early fifties, estates and zamindaris were abolished and the estate forests were taken over by the government. In 1952, the second National Forest Policy was enunciated which laid down that 33.33 per cent of the land should be under forests. In 1956, the states were merged with the Indian Union and all the forests in the country were brought under the management of the states and the forests hitherto managed by *panchayats* were taken over by the government.

During the first three five year plans, very little development occurred. In the Fourth and Fifth Plans, however, large scale planting activity and improvement of communications received needed attention.

In 1976, the government appointed a National Commission on Agriculture and its report has been published in Chapter 9 to cover the forests. This report makes recommendations on all aspects of forestry, namely, protection, production, research and education.

CHAPTER 2

FOREST AND FORESTRY

Definition of a Forest

The word 'Forest' is derived from the Latin word 'Foris' which means 'outside'. Therefore, forests are areas covering practically all uncultivated or untended lands covered with rather tall and dense tree growth. The word 'Jungle' denotes whole ranges of trees and shrub growth with a suggestion of wilderness.

Forests are also defined as an area set aside for the production of timber and other forest produce and is under woody vegetation conferring certain benefits on the society.

Ecologically, the term forest signifies a complex organism, composed of distinct biological units called forest communities that have come into being by the combined action, reaction and co-action of a variety of organisms with the complex factors of the habitat that themselves change, both in space and time.

Legally, forests are areas which have been notified by the government, as reserved forest(s) and they may include some blank patches.

In India, whose geographical area is about 32,80,500 sq km, forests occupy about 7,50,300 sq km or roughly 22.9 per cent whereas agricultural or cultivated area is about 46 per cent.

What is Forestry?

Forestry stands for the theory and practice of constitution and management of forests and utilisation of their products. It also stands for scientific management of forests for the continuous production of goods and services. Agriculture deals with the raising of crops and horticulture deals with the raising of fruits and flowers. Similarly, silviculture deals with the raising of forests. Silviculture is applied forest ecology, such as soil conservation, desert control, flood control, pasture management, etc.

Social forestry denotes practice of forestry for the service of the society, that is, to meet the demand for fuel, manure leaf, fencing material, grazing ground, small timber and other economic products and improvement of climate and environment in general.

Forestry has different branches:

1) *Silviculture* refers to certain aspects of theory and practice of raising forest crops; methods of raising tree crops, their growth and after-care up to the time of final harvesting.

2) *Mensuration* deals with measurement of forest produce.

3) *Silviculture system* is the process by which the crops constituting a forest are tended, removed and replaced by new crops, resulting in the production of woods of a distinct form.

4) *Management* is the practical application of science, technique, and economics to a forest estate for the production of certain desired results. It is the application of business methods and technical forestry principles to the operation of a forest property.

5) *Utilisation* is the branch of forestry which deals with the harvesting, marketing, conversion and applying the forest produce to a variety of uses for example, timber, fuel, charcoal, pulp wood, plywood and a host of other products.

Geographical Features and Distribution of Indian Forests

The following are the main features of the sub-continent.

The mountains: Himalayas, Aravalli, Vindhyas, Satpura, Western and Eastern Ghats.

Plains: The Indo-Gangetic Plains, the Deccan Plateau, eastern and western coastal areas.

River basins: Himalayan rivers, rivers emanating from the Central Indian Plateau and rivers arising from the Western and Eastern Ghats.

Forests are found in great concentration on all the mountain ranges. Very little is found on the Gangetic Plain.

The river basins of rivers that have their sources in the Himalaya and the Eastern and Western Ghats have some forests. In Central India, the forests cover the river basins of the Krishna and the Godavari.

Factors of Locality

Factors influencing the occurrence of forest types are:

1) *Climate*: Temperature, frost, winds (Monsoon) rainfall; seasons—rainy season, cold season, hot season—determine the vegetational types.

2) *Basic rocks*: Soil obtained from weathering of rocks, physical structure of soils, moisture content of soil, soil aeration permeability to roots; soil profiles limit the type of forests.

3) *Topography*: Influences vegetation, due to drainage, aspect and altitude.

4) *Biotic factors*: Influences of man and his cattle and animals are at present the most potent factors conditioning the growth of forests. The influences of fires, grazing, shifting cultivation, etc., are adverse to the forest growth.

All the above factors decide the type of forests and given a particular climate, soil, etc., the forests occur in natural entities.

The study of such natural entities is called forest ecology. Forest ecology, like plant ecology, recognises the basis of development of forest vegetation, the actions, reactions and coactions of trees and other organisms with the complex of environment. A particular environment gives rise to a particular vegetational type which is called the 'climax vegetation'. The vegetation type occurring on mature soils in a particular climate has been called 'climatic climax' whereas on immature soils or newly formed soils, the types are designated as edaphic variations of the climatic climax.

The climax vegetation in its turn is limited in its occurrence by edaphic and biotic factors. Thus the types are edaphic or bioedaphic.

In the case of an ancient country like India, where much of the climax vegetation has long been destroyed, biotic and edaphic features are considered more responsible for the present structure, composition, and stature of vegetational types than the climate.

Succession of Vegetation

The phenomenon of succession of vegetation occurs due to the protection afforded to a given area. In a newly formed land along the rivers, in a particular type of climate, the succession tends to reach a climatic climax, provided no one interferes with its development. The succession sets in due to dispersal of seeds and fruits of forest trees by wind, water, animals and other agencies. Species which get migrated, establish themselves in a given locality if they can adapt themselves to the locality factors found therein. The succession in the vegetation type that occurs in a felled forest or cleared forest is called secondary succession, whereas vegetation types which develop on a newly created land, such as along the rivers by silting, land slips, etc., are called primary succession. The climatic climax theory formulated by Clement assumes that all plant communities will in time develop progressively towards a form which is in equilibrium with the prevailing climate and will then be stabilised as the climatic climax. This will be held up in a pre-climax stage by unfertile soil or fire, etc. In many instances a pre-climax forest type is more economical, such as Teak or Sal forest.

Plant Associations

The ecologist's basic unit for plant communities is the 'association' which has been defined as "the largest floristic unit consisting of a definite dominant and a definite habitat" and as being characterised by its definite floristic composition, life form, structure and habitat. It is also defined as a community of definite floristic composition within a formation which later is defined on physiognomy and not on floristics.

Consociations

Consociations are associations of only one dominant species, which generally occurs in temperate forests.

Socies or Societies of trees, is a small group of dominant trees, which go to form consociations.

The climatic factors or locality factors govern the occurrence of plant associations and consociations. The flora of a region represents the sum total of different types and kinds of plants. The vegetation represents the total effect produced by abundance or scarcity of plants. In our country about 30,000 species form the flora of dicots, contributing 11,124 species belonging to 1,831 genera. There are about 125 monocots, of which bamboos are the most important.

Forest Type

A forest type is defined as a unit of vegetation which possesses (broad) characteristics in physiognomy and structure sufficiently pronounced to permit its differentiation from other such units. This is irrespective of physiographic, edaphic, or biotic factors. It is selected in the first place subjectively from the ever-varying cover of vegetation, with the boundaries arbitrarily imposed on what are in fact gradual changes (clines or continua). The classification of forest vegetation into types is meant for practice of scientific forestry.

The possible basis for classification of forest types are: (1) Physiognomy, (2) Structure, (3) Function, (4) Floristics, (5) Dynamics, (6) Habitat, (7) Physiography, and (8) History.

Physiognomy: Includes characters such as evergreen and deciduous habit and such structural or functional features as are associated with very dry (xeromorphic) or very wet (hydromorphic) sites.

Structure: Covers stratification, dimensions, especially height and spacing.

Function: Is taken to cover the common morphological characters of the species occurring together; buttressing, bark form, leaf size and cauliflory, etc., are some other examples.

Floristics: In this the families and genus of the dominant vegetation are considered.

Dynamics: It is generally admitted that all vegetational types are always changing, even if only very slowly. Their presence and growth reacts on soil and at least the microclimate shows a change and this reaction continues to be mutual.

Habitat: The prevailing climate and available soil in the area gives a basis for classification.

Physiography: Aspect and altitudes on hills influence the vegetation types.

History: History of the site where the forest is to be classified gives an important indication regarding the vegetation type.

Another method by which the forest types are classified is by its morphology. Morphological characters have been found to be the most suitable basis for classification of forest types.

Leaf characters: Variation in size and texture and whether the foliage is evergreen or deciduous. The leafless period of deciduous species varies considerably over its geographical range.

Leaf size: In dry regions, generally, compound leaved trees are found and in wet areas simple leaf is predominant.

Stem and root characters: The development of buttresses is noticed in moist climate, where the growth of the tree is very fast and the tree is of gigantic size. It is absent in drier parts. The root system adopted by trees depends on the locality and is generally functional.

Bark characters: In wetter forests the bark is smoother and in dry areas the bark is rough and corrugated.

Thorniness: This character is closely associated with the dry open types of forests, exemplified by the genus Acacia.

Root suckers: These are developed by trees generally in dry areas and deciduous forest where damage is common.

Flowering and seeding: Season of flowering is usually closely related to climatic regime and also varies with forest type. In wet tropical forests some species are in flower at any season. Flowering is dependent on the rise in temperature after the cold season, particularly in temperate zones.

Seed dispersal: It is of great importance in maintaining a forest type.

Factors Determining Forest Type

The type of vegetation in a given locality depends on the climate, the soil and the past treatment, so that a study of these three factors is essential to an understanding of the variations encountered and the interrelationships of the types that are found convenient to differentiate. These three are not independent.

Climate in Relation to Forest Type

Temperature: It is the most obvious factor of climate. It can be broadly related to latitude and the following four zones are differentiated:

		Mean Annual	Mean January Temperature
1) *Tropical*:	Very hot and winterless	Over 24°C	Over 18°C
2) *Sub-tropical:*	Hot with a cool winter	17-24°C	10-18°C

3) *Temperate*:	With a warm summer and pronounced winter	7-17°C	1-10°C
4) *Arctic:*	With a short summer and long winter		Under 7°C Under−5°C

Floral Regions

The floristic composition and therefore the structure and appearance of a forest type depend on the local flora. The flora of India varies considerably in different parts of the country, both in specific identity and number of species. Comparative studies have led to the differentiation of floristic regions. The following nine are now usually recognised:

1) Western Himalaya
2) Eastern Himalaya
3) Indus Plain
4) Gangetic Plain
5) Central India
6) West Coast
7) Deccan Plateau
8) North-East India (Assam)
9) Andamans & Laccadive Islands

Structural Characters

Stratification: It is frequently observed in a forest that the trees, shrubs and herbs appear to be differentiated into several layers or strata.

Climbers: These are present in moist types. They are extensive in semi-evergreen types and moist deciduous types, less in thorn forests and mangrove forests.

Ephiphytes: Are common in wet evergreen forests.

Biotic influence: Evidence of past clearings may persist in a variety of forms. Fire and grazing play an extremely important role in determining the forest type now occupying the land. These practices when continued, almost invariably have the effect of rendering the site less favourable to tree growth.

Thus the forest types of India as recognised now are:

1) Tropical wet evergreen forest.
2) Tropical semi-evergreen forest.

3) Tropical moist deciduous forest.
(southern and northern forest types).
4) Littoral and swamp forests.
5) Tropical dry deciduous forest.
6) Tropical thorn forests.
7) Tropical dry evergreen forests.
8) Sub-tropical broad leaved hill forest.
9) Sub-tropical pine forest.
10) Sub-tropical dry evergreen forest.
11) Montane wet temperate forest.
12) Himalayan moist temperate forest.
13) Himalayan dry temperate forest.
14) Sub-alpine forest.
15) Moist alpine scrub.
16) Dry alpine scrub.

Forests were classified into several types by H.G. Champion in the late thirties. These types were again revised and redesigned in 1965 by H.G. Champion and S.K. Seth. Under each broad type there are several sub-types based on the available dominant plant associations.

The above types are called natural ecosystems. Ecosystems are the natural climax forests, resulting from a long process of ecological succession of plants and associated animal life, undisturbed by man.

Artificial Ecosystems

These are created by the introduction of species through plantation, such as teak, eucalyptus, pines, etc. The introduction of species is made considering their nature and climatic requirements. Thus artificial ecosystems are created.

CHAPTER 3

FUNCTIONS OF FORESTS

Importance and Functions of Forests

The following are the important functions of a forest cover:

1) *Productive*: They provide timber, fuel, charcoal, *beedi* leaves, wax and resins, fruits, tanning materials, manure leaves, grass, bamboo, gums, lac, etc.

2) *Protective*: Forests protect water sheds, catchments of rivers and streams against erosion.

3) *Aesthetic*: Forests add good appearance, landscaping and a thrilling atmosphere to the locality.

4) *Recreational*: Forests provide picnic resorts, and opportunities for sports like hiking, trekking, wildlife watching, bird watching.

5) *Scientific*: Study of ecological processes can be made.

6) *Ameliorative*: Forests improve climate and reduce pollution.

7) *Hygienic*: Forests improve the environment and help in reduction of noise, purify the air and give out oxygen to the atmosphere.

8) *Industrial development*: Forests meet the need for raw materials for industrial development such as paper pulp, rayon grade pulp, saw milling, hardboards, particle boards, plywood, etc.

Importance and Functions of Forests in Rural Economy

Forests provide firewood, timber for agricultural implements, housing, fencing material, bamboos for baskets and huts, sericultural industry, minor forest products such as honey and wax. They provide employment particularly to tribals and generally add to better agricultural yields.

Indirect Benefits of Forests

Vegetation conserves moisture, renders cover, induces fauna to appear; brings in wildlife, and trees and shrubs with succulent fruits; brings in many birds which control insect pests.

The tree influences provide a major defence against environmental pollution. Trees work as a signal to a critical stage of air pollution. Tree lands are the habitats for a large number of insectivorous birds, which prey on insects harmful to agricultural crops. Snakes and wild cats are also sheltered which prey on rats. Of the 250 species of snakes, about 80 per cent are predators of rodents.

A tree is the cheapest large scale parasol one can produce and the only kind that will last for years without renewal, shielding us from the sun, frost, rain, wind and other people.

As Patience Strong said:

> "Within their cool and friendly shade
> We may find peace and rest
> And look into a quiet green place, where birds make melody
> This is God's greatest gift to man—the Glory of a tree"

A good forest cover on the catchments of big projects increases the life of the projects. Projects estimated to last for centuries, might survive for a short period of 50 to 60 years, if silting of their reservoirs is not controlled. In an area which is fairly covered with trees, the maximum run off of rainwater is less than 100 cusecs per square mile, while in the land where persistent cattle and buffalo grazing has destroyed the plant cover, the run off rises to 1600 cusecs per sq mile.

The spread of the river beds with resultant floods is another problem which results from removal of vegetation cover.

"Forests attract rain-bearing clouds and help in precipitation."

It is rightly said that forests are the foster mother of agriculture. They are the green blood of mankind.

Management of Forest for Sustained Yield

The forests are managed under certain silvicultural systems, appropriate to the type, age and locality of the forest.

These silvicultural systems are:

1) Clear felling and planting.
2) Clear felling and leaving the area to reproduce naturally.
3) Selection felling.
4) Coppice with standard.
5) Coppice with Reserves.

The idea in harvesting a forest is to extract only the increment put on by a forest block. Considering this principle, working plans are prepared for each forest division. In hilly tracts and in some over-exploited areas no extraction is carried out and such areas are called protected forests. However, dead and dying trees are removed by selection. The yield of a forest is regulated either by volume of the produce or by area or by number of trees. Illicit removal and illegal fellings upset these calculations. Due to a heavy increase in population and consequential increases in demand for forest produce resulting in high market prices, illicit fellings and destruction by unlawful elements is on the increase. The result is that scientific management gets badly affected, upsetting the calculations. To reclothe much of the denuded areas in the forest and to meet specific industrial needs, large scale plantations are being taken up.

The National Commission on Agriculture in its report on forestry, envisaged the country's need for fuel and small timber and has recommended to raise plantations and man-made forests over 1 lakh ha in the first decade with an outlay of Rs. 242 crores and in the second decade the envisaged outlay is about Rs. 306 crores. On development of forest-based industries and to meet their raw material requirements in the current decade Rs. 815 crores are estimated to be spent. Of this Rs. 611 crores will be spent for pulp and paper production. During the next decade the expenditure is likely to be of the order of Rs. 1187 crores.

To raise finance for such programmes, institutional machinery has to be tapped. For this purpose, Forest Development Corporations are created in almost all the states.

Social Forestry

It is now a known fact that forests are essential to fight drought and the government has identified such areas which are chronically affected by drought. In all such areas, it is envisaged to raise plantations in over 3 lakh ha and raise avenue plantations over 8000 km of roads and 1 lakh acres of shelter belts and wind breaks. The National Commission on Agriculture has estimated an outlay of Rs. 77 crores, including that for research, during the Fifth Plan for the country as a whole. For creation of parks and picnic corners, which come under recreation forestry, an outlay of Rs. 10 crores is envisaged and 50 per cent of this will be met by the central government.

Forestry Training and Research in India

As we have seen above, the future plans are ambitious and they need personnel to implement them. To provide training in forestry works, we have several colleges and schools. Almost every state has forest schools for training foresters and forest guards.

The Indian Forest College trains the officers of the I.F.S. and Asst. Conservators of the Provincial Service. In addition, the Forest Research Institute provides specialised training in wildlife management, soil conservation, logging and other refresher courses.

For training the Range Officers, we have colleges at Dehra Dun and Coimbatore and one was recently opened in Assam and another at Chandrapur.

As forests are recognised to be the foster mother of agriculture, it was felt that the agricultural universities should also offer a course in forestry for their undergraduates, to start with as an elective, and also impart practical knowledge to raise nurseries and plantations, etc. At present the agricultural universities of Himachal Pradesh, Karnataka and Tamil Nadu have established this course. The Andhra Pradesh Agricultural University has commenced the course since 1977.

Research in Forestry

The Forest Research Institute at New Forest, Dehra Dun is the premier institute conducting research on almost all the problems. In addition, we have Regional Forest Research Stations at Gauhati, Bangalore, Coimbatore and the Arid Zone Research Station at Jodhpur. The states have a research wing manned by silviculturists, working under a conservator of forests.

The report on forestry by the Agricultural Commission recommended active involvement of agricultural universities in research of basic problems of forestry. The Government of India has earmarked some funds for this work.

Current Trends in Forestry

Till recently the management and administration of forests the world over was conservation oriented, the forests were managed to remove only the increment put on and the capital was never touched. The current trend lays more stress on dynamic production forestry. This is so because forests form only 1.6 per cent of the gross domestic product, whereas agriculture forms 46 per cent. Again, 0.2 per cent only of the rural working force are engaged in forestry works. To generate higher employment potential, forestry-oriented management to increase production is aimed at. The past management aimed at producing timber and trees and generally the species were also limited. The current trend is more production of pulp wood. It is now realised that forests are the only renewable source of energy, they alone are capable of harvesting solar energy to a large extent.

Industrial and Social Demands

The demand for forest produce is from all sides; man needs a cradle at his birth and a coffin at his death.

Timber is required for defence, railways, navy, building construction, etc. Pulp wood for over 60 paper mills is to be met; there are four rayon mills and some more are proposed. There are 32 plywood factories and many more are coming up. Match factories, about six in number, need large quantities of soft wood. There are several cottage industries manufacturing matches which are to be supplied with wood. Slate frames, furniture and other handicrafts need wood.

In the rural areas, carts, cart wheels, ploughs and firewood are to be supplied.

To meet all the above needs, forests have to be preserved and they have to be enlarged.

The second function of forests is to control erosion by wind and water. A forest cover is essential for this purpose.

With the advancement of industries, and the consequential creation of large towns, with the resultant increase of noxious gases, etc., pollution of the atmosphere will increase. As already stated, trees and vegetation reduce and combat pollution. The forests and trees play an important role in this aspect.

Thus the general environment has to be improved by having more tree lands, which help the growth of a healthy population.

Injuries to Forests

Forests suffer many onslaughts of nature, man and his cattle. There are several types of injuries which destroy or mutilate the forests. The injuries to forests can be divided into two classes—one is natural and the other is artificial. Natural injuries are due to floods and frost, snow and wind, insect pests, fungal diseases, drought, etc.

The artificial injuries are those created by man and his animals.

Man clears the forest for cultivation, illicit trade in forest trees and shifting cultivation in which an area is cleared and cultivated for a couple of years and abandoned.

People living near the forests, continuously cause heavy damage to the forests, they fell trees to make money. They indiscriminately remove leaves for green manure without following any scientific method. Removal of young trees for fuel is very common. In areas where there is good grass, people set fire to it in the belief that fire will give rise to a good and new flush of grass. Fire in fact has the worst effect on forests and it makes the succession proceed in a negative direction, ultimately resulting in the creation of blanks or poor scrub. Fires in the forests are caused by passersby and people living near about, either through negligence or incendiarism. Fire is highly destructive in coniferous forests as the tree growth there is highly inflammable due to resinous exudations. Fires are caused by people collecting mohwa flowers for distillation. On a forest covered with fallen leaf, the mohwa flower collection is laborious. If the debris is burnt, a clean floor is available to sweep the fallen flowers. Fires are also caused by people collecting *beedi* leaves. During February/March the villagers set fire to the leaf debris on the floor of the forests which scorches the *beedi* leaf seedlings which with a shower throw up a good flush of leaves.

The fires in forests are also used to prepare sites for raising plantations and as a weapon to reduce weed and grass growth. Such fires are controlled fires.

Heavy grazing by sheep and cattle causes equally severe damage. The hooves of cows, bulls and buffaloes trampling the forest floor harden the floor which is called 'Caye's hardening'. A hard floor becomes inhospitable to receive seed, thus affecting the natural regeneration of forest species. Overgrazing also affects regeneration, as cattle eat away all the growth and sometimes the leaf debris as well, which thus is not available as a natural manure to the forest soil. Goats when let into the forests, cause the maximum damage as they are voracious browsers and they nibble at the young seedlings and growing buds. Goat browsing in forest is prohibited. In Pakistan, in fact, rearing of goats is said to have been banned. Similarly, camels cause heavy damage to forest growth.

Grazing has to be controlled and should be restricted to the carrying capacity of the forest area. Otherwise evil effects of heavy grazing will be sustained. In some states, rotational grazing is being tried by closure of the areas for a period of three to four years.

In the absence of good soil cover due to fires and grazing the rain falling on the forest floor causes erosion, which in hills manifests as rills and expands to gullies and ravines and makes the soil infertile to hold tree growth. The run off of water carrying the soil with it spreads the debris in the rivers which widen out due to shallow beds and thus cause floods.

Another agency which is causing heavy denudation in forest areas is the construction of power projects, large reservoirs, etc. Forests get submerged in the reservoirs. Forests are cut down to rehabilitate villages, which would be submerged in the reservoirs. Forests in the command areas of the projects and reservoirs are generally chosen for the purpose. In addition, forests are cleared to rehabilitate refugees and transferred population. We have examples of Bengal refugees settled in Dandakaranya and Andhra Pradesh, Tibetans in Karnataka, Ceylonese and Burmese in Andhra Pradesh and Madhya Pradesh.

Forests are further affected due to clearance for electric transmission lines and posts and telegraph lines. Creation of big industries such as thermal stations, fertiliser plants, etc., and the townships established round them take away big chunks of forests.

Due to the extensive damage to forests, tree vegetation is being reduced and blanks are being created. In fact, the oldest civilisations of Mohenjo-Daro and Harappa vanished due to these people clearing the forests and vegetation to burn bricks for their unreasonably huge granaries. To see that our civilisation does not suffer a similar fate, social forestry is proposed to be practised on a gigantic national scale.

CHAPTER 4

CAUSES FOR DESTRUCTION OF FORESTS

India had luxurious, extensive forests in the past. It is said that the extensive formidable forests prevented the onslaught of Alexander the Great and other invaders from raiding the southern part of the country.

With the spread of civilisation and population forests were felled to cultivate annual crops, build habitations and towns etc. Such activity reached an accelerated pace after the Second World War. Even in the fifties, the country had a comfortable extent of forests, more or less conforming to the norms that one-third of the land area should be under forest cover, and the distribution of the same was envisaged at 60 per cent in the hilly and mountainous tracts and 20 per cent in the plains. In the eighties we find that the forest areas have considerably shrunk and hardly 20 to 25 per cent of the country's land is under forests with the distribution erratic and vast areas with no tree cover. The beneficial effects of forests if they are to be made widely available, should be well distributed. The following are some of the reasons for depletion in forest cover.

1) With the First and Second World War, considerable forests were felled to meet the needs of war. In that period, even the railways used to be run with fuel wood obtained from forests.

2) In the post-Independence period a large number of reservoirs and dams were constructed to impound water for irrigation and power generation. As a result extensive forests were lost due to submergence and rehabilitation of the displaced families from villages which came to be submerged.

3) The Grow-More-Food campaign of the fifties led to the cultivation of lands over vast areas, even lands which had luxurious forest growth. Many a times this assignment to cultivation was of lands which had no soil potential to sustain

agriculture.

4) Due to excessive cattle population, most of it scrub type, incapable of any service, either by way of milk or muscle power, the forest floors were over-grazed. All the regeneration in the forests was completely damaged and this resulted in loss of future crop in the forest. Heavy grazing also led to the hardening of the soil surface, due to which the seed from the mother trees, did not germinate and root in the soil.

5) Due to the population explosion and high rate of unemployment, more particularly in the rural belts, a large number of people eke out their daily wage by selling head-loads of fuel. A stream of people carrying head-loads from the forests to the nearby towns is a common sight in the forested belts. This large scale removal of head-loads of fuel is a slow but sure cause for the depletion of forest.

6) The construction activities in the cities and the housing demands in villages, due to developmental schemes etc. created a high demand for timber. The prices soared by leaps and bounds and this developed a class of unsocial elements who indulged in illicit felling and smuggling. They were induced to the extent that criminal gangs were engaged to intimidate and assault the government officials. More often the poor tribals and other unemployed villagers were made to fell the trees, convert them into timber and bring them to specified spots for paltry sums. The smuggler then disposing the produce in bulk, clandestinely, adopting devious methods. A large number of people entered this trade to make a quick buck. Though stringent laws with punishments, and with provision to confiscate vehicles were adopted, the unscrupulous elements could not be contained.

7) The dry deciduous forests, shed their leaves in summer, and this leaf litter, particularly of teak and its associate species, are fire prone. The villagers passing through the forests negligently throw lighted *beedis* or match sticks, which set fire to the leaf litter. The villagers collecting mohwa flowers, set fire to the debris below the trees, to clean the ground for easy collection of the flowers and this fire spreads in the forests. The belief that grass if burnt throws up a better flush with rains has led the villagers to set fire to the grass cover. As a result the fire destroys the leaf litter, which otherwise would have decom-

posed to form good humus and nutrition for the forest trees. Further due to the leaf litter getting destroyed, the forest floor becomes bare and the onset of rains then causes heavy run off which also carries the good top soil with it. Due to overgrazing and annual fires, the forest soil has lost all its fertility and the top soil has been eroded to a large extent. This has led to the failure of one of the major functions of the forest, to conserve moisture and rain water.

The above factors of destruction are termed as biotic influences, which when they reach extreme levels, destroy the vegetation and the land becomes barren, unproductive and which in turn effects the equilibrium in nature, creating floods, droughts spreading misery.

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CHAPTER 5

DISEASES DUE TO DEFORESTATION

The Mohenjo-Daro and Harappan civilisations as also Mesopotamia were thriving and progressive. These great civilisations were ruined and their existence on planet Earth is forgotten except for stray archaeological remains unearthed during excavations. There are many theories as to why these civilisations vanished, the most plausible among them being ruthless denudation and destruction of the forests.

Bricks were known to these ancient civilisations. To store the grain from their harvests, they used to construct huge granaries enclosed with very thick brick walls. To manufacture this large quantity of bricks they needed fuel wood, for which large tracts of forests and tree growth were felled. This led to their ultimate ruin.

The spread of deserts, drought and floods are direct results of destruction of forests. All these three calamitous occurrences are due to the destruction of forests and tree vegetation. All the three in their wake bring in diseases, epidemics and death.

In a survey carried out among the American troops during the Second World War, it was established that men from the 'Wild West' of America, had better health and stronger teeth. The western region of America is a forested tract fairly dense and reasonably well preserved. Thus a relation between the general health of the habitants and the vegetation is obvious.

Deforestation brings in floods in hilly regions. In our own country, affected by frequent floods, particularly in the hilly and undulating terrain of the Himalayan foothills and Nepal, have widely spread occurrences of the disease "Goiter". A deadly infection which leaves a person lazy, listless and very often mentally retarded. Goiter is caused by iodine deficiency. Like the water-cycle and the oxygen-cycle, there is what can be called an iodine-cycle.

Iodine is a volatile substance which is found in the atmosphere in a gaseous state. The soluble iodine is brought down by rain. Due to floods, the soluble iodine is washed off and is carried away swiftly by streams and rivers, causing deficiency of this element both in the micro atmosphere and also in the stored water of the sub-soil. A person needs 0.15 mg of iodine per day for his thyroid gland to function normally; when this quantity is not available the said gland malfunctions and Goiter sets in. It is said that the government has to incur considerable expenditure to supply iodised salts in the regions where Goitre is an epidemic. To maintain the iodine-cycle, forests on hills and mountains are very essential, to prevent floods and retain iodine.

Another deadly diseases which causes men great misery is due to excessive fluoride content in water from draw wells and bore wells. Fluoride when it exceeds 0.2 PPM in concentration in potable water, leads to thickening of joints and causes heavy pain. This is a very painful disease which makes life a living hell. This excessive concentration of fluoride in water is noticed commonly in districts which have very little or negligible forest cover. By inference therefore, it can be said that fluoride in water is high where the forests . are destroyed or neglected.

A town or a city with no tree vegetation, by way of avenue trees, gardens and parks, has little scope to provide pure unpolluted air to the inhabitants. More so, in industrial towns and factory premises, the pollution due to effluents comprising generally carbon monoxide, sulphar dioxide and other noxious gases, leaves very little fresh air in the atmosphere. This leads to several diseases, commonly affecting the lungs and the heart.

Due to the destruction of the forests, the soil gets eroded and noxious thorny and bushy growth neither palatable for cattle nor capable of stopping erosion, develops. In many parts of the country people use goat's milk in their daily diet. Goats are voracious browsers and they thrive on many weeds, which normally other cattle do not relish. One such weed is called Argemone mexicana. The fruits and leaves of this weed contain an alkaloid, which is harmful to the eyes. Goats which browse on this weed carry the harmful effects of the weed in their milk, which when consumed leads to opaqueness of the eyes and ultimately may lead to blindness. It is believed that the spread of this disease of the eyes has a direct relationship to the spread of this thorny weed. There may be several other weeds which might lead to many other diseases, but have not been surveyed and correlated.

An undisturbed and good forest cover sustains many medicinal plants, whose roots, tubers, fruits and flowers provide antidotes for several ailments. A naturally grown medicinal plant provides better remedies without reactions than the synthetically produced medicines. Unfortunately destruction of vast stretches of forests have caused the extinction of many species of medicinal value, and as already stated brought in several noxious weed growths.

Drought and famines, ill health and diseases, floods and cyclones and several other calamities which threaten a civilisation are directly linked to denudation, destruction and removal of forest cover. If civilisation is to thrive and a nation is to prosper, forests and tree vegetation, well distributed in all corners of the country, are a must. The civilisations which vanished have left us a grim lesson to learn from such follies that led them to ruin.

No neutron bomb is needed to cause widespread damage or destruction, for a country which is destroying its forest cover.

CHAPTER 6

SOCIAL FORESTRY

Social forestry is the greatest instrument of land transformation. Consider the number of trees which we will have if each farmer raises even 10 trees on his farm land. The figure and yield will be colossal and its effect on the economy will be very impressive. If each tree is harvested say at the 10th year, the farmer having 10 trees will earn nearly Rs. 400 at Rs. 40 a tree. This is with an initial expenditure of about Rs. 10 only. This increases the area under trees for the benefit of the community as a whole and the rural community in particular.

Development of trees on agricultural and other waste lands has tremendous effect. The trees control sheet, rill and gully erosion, retain soil moisture, provide the farmer with fuel and timber for agricultural implements, improve the climate, provide recreation to people, save cowdung for manure and wood required for cremation which is sometimes scarce. Fuel wood alone to the extent of 81 million tonnes is consumed annually and by 1980-81 it was estimated that about 150 million tonnes of fuel wood would be needed. Again, it is said that about 400 million tonnes of cowdung equivalent to about 60 million tonnes of fuel wood are burnt annually in our country. That means the total fuel wood requirement will be to the order of 210 million tonnes. With forest yield being diverted for industrial purposes and the extent dwindling year by year, the only possible recourse will be to make the farmer grow trees on his farms. This has been achieved to a great extent in Punjab and Haryana and parts of Uttar Pradesh.

Social Forestry Practices

The social forestry practices include:

1) Raising wind breaks on dry farm lands.

2) Planting shelter belts.

3) Planting along road sides intensively.

4) Planting in the village common lands and waste lands.

5) Planting along railway lines and canal banks.

6) Planting small wood lots on the farm if it is large.

7) Planting of gardens near villages and along highways for recreation and rest.

8) Planting foreshore areas of irrigation tanks.

9) Planting of saline and calcareous soils unsuitable for agriculture.

10) Reclamation of waterlogged areas or areas susceptible to inundations by planting trees.

11) Planting of river and stream banks and training the rivers.

12) Reclamation of highly eroded lands and controlling erosion.

13) Raising of trees on soil conservation bunds.

14) Planting of trees in urban areas—environmental planting.

15) Raising of irrigated plantation of teak and mulbery.

16) Afforestation of command areas of irrigation projects.

Recreation Forestry

This aims at preservation of forests in compact blocks or development of small blocks of man-made forests of miscellaneous trees offering shade and shelter, creating facilities for recreation of people--such as picnic corners, zoos, facilities for hiking, riding, boating, etc., and establishment of natural history museums.

Methods and Practice of Social and Recreation Forestry

Social forestry may be sub-divided into farm forestry, extension forestry and urban forestry. Practice of forestry on farm lands is farm forestry. Practice of forestry outside the farm lands and outside the reserve forests is extension forestry. Raising of tree crops in urban areas is urban forestry.

Farm forestry: Includes raising of wind breaks, shelter belts, farm wood lots, raising trees in village common lands, etc.

Extension forestry: Includes raising tree crops on canal banks, railway lines and road sides, under high tension electric lines, irrigated plantations of forest trees, afforestation of foreshore areas of tanks and reservoirs, reclaiming lands unsuitable for agriculture with tree crops.

Urban forestry: Raising of tree crops in urban areas as a forest or for amenity planting to prevent and minimise pollution.

By now it is well appreciated that there is essential need for social forestry programmes and farm forestry development. Now we will deal in detail the social forestry practices.

Shelter Belts and Wind Breaks in Dry Land Agriculture

Vast stretches of cultivable lands in our country are set apart for dry land agriculture. Dry land agriculture depends mainly on the monsoons and some crops such as jowar (Sorghum) thrive well with dew formation.

The success of dry crops depends upon the available moisture in the soil and the period of its availability.

The moisture availability in soil depends upon the quantum of rainfall, the frequency of rainfall, the *texture* and retention capacity of the soil and lastly the factors which control the evapotranspiration. The loss due to evaporation is sometimes very high in exposed and wind swept tracts. The higher the wind velocity the higher the loss due to evaporation. This factor of wind velocity can be controlled by planting what are called *shelter belts*. These belts consist of rows of trees and shrubs, planted along the field borders at right angle to the prevailing high velocity winds. In the peninsular region of the sub-continent, the prevailing high velocity winds are from the south west on the western half of the country and the northeast in the eastern half of the country. Therefore, the shelter belts can be planted northwest to southeast, in almost all localities.

The practice of planting shelter belts is in vogue in Germany and the United Kingdom. They had experimented and established the benefits of such belts as early as in 1910. In the United Kingdom these belts were popularly grown in Edinburgh and Scotland.

The belts are three to five rows of trees and shrubs with a conical cross section, that is, towards the windward side shrubs and bushes are planted close to each other, the second row will have medium sized trees and the third row tall trees and then in the declining order. The effectiveness of the belts extends towards the leeward side up to 20 to 30 times the height of the belts.

Generally in the first row Agave, Sitaphal, Falsa (Grewia spp.) and small flowering shrubs are planted at 0.5 to 1 m distance. Average height of this row is 1 to 2 m. In the second row trees of 5 to 8 m height such as Sesbenia, Glyricidia, Kubabul are planted. The last row and middle row of the cone, tall trees of Eucalyptus, Casuarina, Casias are planted at 1.5 m to 2 m spacing, whose height may reach 10 to 15 m. The rows are spaced at a 3 m distance. In the coastal belts Cashew also can be introduced in the second row, in which case the branches need to be pruned. Other fruit bearing species like Guava, Pomegranate and Ber are also raised for their economical value. If space is available and can be spared, a row of bamboo clumps at 5 m spacing is introduced in the fourth row, as bamboo is of high utility.

In an experimental study in the Agricultural College at Rajendranagar (Hyderabad) and Tirupathi it was seen that the yield of crops such as Bajra, Groundnut and Green gram, showed an increase of 25 to 30 per cent. After harvesting of the crop at Tirupathi the moisture available in the soil was capable of sustaining another short duration crop of fodder value.

These shelter belts when planted along the irrigated lands, help in reduction of number of irrigations. Such belts planted around the plantain (Banana) fields will reduce the incidence of leaf tear and damage to leaf and in case of Mango and other horticultural crops, the flower and fruit drop due to wind will be considerably reduced. The benefits accruing as a result of planting of shelter belts are:

1) They reduce the wind velocity blowing over the crops and this reduces the evaporation losses.

2) The reduction of wind velocity helps in large exposure of the stomatal apertures, thus extending the period of photosynthesis on the leaf surface. The higher photosynthetic activity helps in better and healthier growth of crops.

3) It is recorded that the dew formation in sheltered areas increases by 200 per cent. This is an important factor for the crops which thrive well in winter such as Sorghum, Horse-

gram etc.

4) The shelter belts provide a place for the snakes to live and multiply, which in turn prey on the rats, the major cause of damage to grain.

5) The birds nesting on the shelter belts are agencies to prey on the insect pests, which damage the crops, such as Bayas, who feed their young ones with insects. When the crop is harvested, the birds live on the seeds of weeds, thus reducing the weed population in the fields.

6) The birds nesting on the trees of the shelter belts, add good manure through their droppings.

7) There is perceptible movement of soil particles when the wind velocity is high. The shelter belts by reducing the wind velocity, prevent such movement of the fine particles of top soil and effectively prevent wind erosion.

8) The species planted as shelter belts yield, fruit, fodder, fuel, small timber for the farmer and thus add to the agricultural income.

9) The belts regulate the weather by reducing high summer temperatures and increase the low temperatures of winter.

10) The continuous and vast stretches of shelter belts add to the increased precipitation from cumulus clouds.

Considering the various advantages of raising shelter belts the National Commission on Agriculture, in its report of 1976, recommended acquisition of a narrow belt of land in the cultivated fields and raising of shelter belts. But this is a stupendous job which cannot be successful without the active cooperation of the farmers. It is, therefore, necessary that larger land holders take up such programmes by themselves and establish benefits of such belts.

The expenditure incurred on such raising of shelter belts is largely compensated by the various products produced by the belts, such as fruit, fodder, small timber and fuel. The practice of burning farm yard manure for domestic energy, will thus be curbed as fuel from the belts can effectively substitute the energy source. Further, due to increase in soil fertility the use of fertilisers, which are costlier can be reduced.

There are objections to raising of shelter belts due to the shade cast by the belts. This fear is dispelled by the fact that the shade from a belt of northwest to southeast, is not much.

Further, this shade from the belts, might effect a small portion of the field and any small loss in the yields is made good by the increased yield in the farther parts of the field.

Another fear expressed is the possible root competition arising between the roots of the trees and the crop. This is not correct, as the tree vegetation taps a deeper zone of subsoil and the crops thrive on the soil moisture in the first few centimetres of the soil. Even then a shallow trench dug up parallel and close to the belt can effectively arrest the spread of roots in the fields.

Biological methods to increase the yields will go a long way in improving the fertility of the land, creating a salubrious environment and make the country prosperous.

Planting of Wind Breaks

Rows of trees along field margins, as far as possible perpendicular to the most high velocity wind of the locality constitute wind breaks. Roughly seven per cent of the total area should be planted for effective protection. The breaks are raised by planting two close rows of fast growing deciduous and one parallel row of slow growing of longer living evergreens (Tamarind). As far as possible dense crowned tree species are to be selected.

Species Suitable for Wind Breaks

Dry and arid regions: *Casuariana equisitifolia*, *Pongamia glabra*, *Azadirechta indica*, *Acacia planifrons*, *A. auriculiformis*, *Tamarindus indica*, *Albizzia lebbek*, *Peltophorum ferruginea*, *Dalbergia sissoo*, *Melia azadirechta*, *Tamaris articulata*, *Eugenia jambolana*, *Mangifera indica*, *Ailanthus excelsa*, *Sesbania grandiflora*, *Moringa pterygosperma*, *Eucalyptus* hybrid, *Eucalyptus citriodora*, *Artocarpus integrifolia* and *Grevillea robusta*.

For coastal areas: *Anacardium occidentale*, *Ailanthus malabarica*, *Acacia auriculiformis*, *Casuariana equisitifolia*, *Pongamia glabra*, *Thespesia populnea*, *Calophyllum inophyllum*, *Mangifera indica*, *Grevillia robusta*, *Cassia siamea*.

Shrubs and grasses: *Agave* species, *Sesbania aegyptica*, *S. aculata*, *Glyricidia maculata*, *Cassia auriculata*, *Vitex negundo*, *Dudonea viscosa*, *Euphorbia tericulli*, *Jatropha* spp., *Thevetia neirifolia*; Grasses: *Saccharum*, spp., *Cynodon dectylon*, *Elusine cor-*

acana, *Cenchrus ciliaris*, *Euleopsis binata* and other fodder grasses.

Suggested Pattern of Planting

The perimeter of an aere is 400 metres. If a tree is planted every 2 metres, 242 trees can be planted:

	Dryland	*Wetland*
Tamarind	4	...
Artocarpus species	4	...
Casuariana/Eucalyptus	100	200
Glyricidia	80	42
Pongamia	30	42
Sapota	4	...
Albizzia lebbek	4	...
Neem	6	...
Acacia arabica	6	...
Bamboo	2-4	...
Sesbania	2	10

Shelter belts should be in one or more rows of trees. As the sheltered area is 15 to 20 times the height growth, the protection afforded will many a time cross the fields of the farmer. Therefore, raising of these belts should be on a cooperative basis, as holdings are small. The practice of raising shelter belts and wind breaks can be adopted before planning agriculture on treeless tracts or large farms. For this effort, the leadership has to be strong.

The belts are triangular in cross-section. Tall trees are planted in the centre and shorter ones along the sides. A mixture of species is advisable. As far as possible species should be selected on the basis of their coppicing power. Spacing should be 1 metre for shrubs, 1.5 m for trees in rows, each row being 1.5 to 4 m apart and there should be five rows for proper protection.

Objections to Raising Shelter Belts

1) They harbour cattle, browsing animals, rodents, etc. The objection is more theoretical and can be overcome by keeping a watch for the period when there is a crop.

2) Roots of trees compete with agricultural crops. This can

be overcome by removing the roots to a distance at half the tree height. Digging a small trench of 22 cm depth will serve the purpose.

3) Shade affects the crops. This is insignificant when compared to loss of yield by patchy cultivation in dry land. The shade effect will not be there for the first six to eight years by which time yield from the trees outweighs the loss due to shade.

Raising of Wood Lots and Afforestation

These are raised on lands unsuitable for cultivation. Every village must have at least 10 per cent of its cultivated area relegated for this purpose. If there are no uncultivated areas, or the entire land is cultivable, even then 10 per cent must be set aside for this purpose. These wood lots are meant to provide small timber, fuel, usufructs, manure leaf, etc. These wood lots will be the property of the whole village and the benefits should be utilised for the betterment of the village.

Species suggested are as follows

Marshy and waterlogged portions should be planted with *Salix tetrasperma*, *Sesbania grandiflora*, *Eugenia jambolana*, *Bischofia javanica*, *Bambusa arundinacea*. In calcareous soils, *Agave* should be raised. In village waste land/common land, *Eucalyptus* hybrid, *Azadirechta indica*, *Pongamia glabra*, *Albizzia lebbek*, *Acacia arabica*, *Bassia latifolia*, *Casuariana equisitifolia*, Soapnut (*Sapindus emarginatus*), *Acacia concianna* and *A. auriculiformis*, can be planted.

Afforestation of Canal Banks

With the stress on irrigation and power projects, in all the states, we have very large and extensive canal systems. The canals are dug up and the excavated earth is heaped on one or both sides. These banks or embankments are poor in their fertility. They need to be protected from erosion, which starts with rills and slowly gullies are formed and these thus create breaches in the canal. Tree growth protects the banks and also prevents evaporation of the water in the canal. Canal bank plantations also serve as shelter belts to many fields adjoining the canals. Further, for each canal system there is a statutorily specified width up to which cultivation is restricted. These belts or strips are also available for growing tree vegetation.

Species suitable for canal bank plantations are those which can yield fuel, pulpwood and timber. Bamboo and teak if raised in suitable well drained soils, will prove of high economic value. Bamboo can be harvested every three to four years. The other species recommended are *Eugenia jambolana*, *Dalbergia sissoo*, *Mangifera indica*, *Acacia arabica*, *Ailanthus excelsa*, *Terminalia arjuna*, *T. belerica*, *Pongamia glabra*, *Madhuca latifolia*, *Tamarindus indica*, *Azadirechta indica*, *Sesbania* spp., *Eucalyptus* spp. and *Casuariana equisitifolia*.

In soils with stony outcrops and gravel, Agave species can be successfully established.

Punjab, Uttar Pradesh and Haryana have raised to a considerable extent canal bank plantations.

Afforestation of Railway Line Sides and Under High Tension Lines

There are over 45,000 km of railway lines in our country. Many of the tracks are formed over embankments and or are in cuttings and plains. On either side of the lines a narrow belt of 10 to 15 m of land is available for planting.

In summer it is extremely uncomfortable to travel in the trains. The noise created by the trains is unbearable. If tree growth is raised on these extensive belts, they will reduce the heat and the sound. Trees would act as noise abators and absorb sound waves. In addition, the tree growth would prevent the direct impact of rain on the tracks and embankments and prevent erosion. These tree lines would also act as a shelter belt for the adjoining fields.

There is no possibility of irrigation or watering the trees along such vast tracks. Therefore, those species should be selected which can withstand the local rigours of the climate. Further, the soil along the tracks is highly variant. The species suggested are: *Agave*, *Arundo donex*, *Saccharum* spp. and *Ipomea* species on embankments. In sandy and loamy soils Teak, *Eugenia jambolana*, *Eucalyptus*, *Acacia arabica*, *Albizzia lebbek* and *Acacia auriculiformis* can be planted. In saline soils *Butea monosperma* is advocated.

High Tension Electric Lines

These lines carry electrical power from power projects to various centres. A very large area in a linear strip of 10 metres to 50 metres is covered by these lines. Rich forest areas are cleared for laying the lines. However, no tree vegetation is permitted to be grown under these lines and the Electricity Act imposes a ban on such planting. Further, much jungle growth comes up along these lines which is cleared by the Electricity Boards at a very high cost. To utilise this belt of land, species which are short and do not interfere with the power lines should be selected or even tall trees grown and pollarded to keep them as a bush. The species so selected should be of utility in distilling oil or use of the leaf, etc., for manuring or grasses of essential oils.

The species suggested are: *Eucalyptus citriodora*, maintained as a bush, lemon grass, baib grass, *beedi* leaves, etc., and medicinal plants like Vinca rosa. Species which are grazed or browsed should not be selected as it will be a very costly procedure to fence these belts.

Afforestation of Roadsides

An 'avenue' is defined as a way of access, an approach to a country house bordered by trees. It has come to mean the row of trees planted along roads and paths.

The concept of planting trees along the roadsides is as old as the Vedas. In the *Padma Purana* it is stated that "Man planting trees by the wayside will enjoy bliss in Heaven for as many years as there are fruits, flowers and leaves in what he planted".

Planting of trees along roads was ordered in the form of an edict by Emperor Ashoka. Feroz Shah and Tughlak in the 14th century ordered planting of trees along the roads. When the capital was thought to be shifted from Agra to Daulatabad the entire population was ordered to move and for their protection from the elements, trees were raised along the roads. Many of the old trees found along roads and canals, are 100 to 200 years old and some are even older.

The following are the objects in raising trees along the roads:

1) Assistance in increasing agricultural production by way of

shelter belts, provide fuel wood to divert cowdung to fields, reduce damage of sugar cane and cotton from desiccating winds, reduction of evaporation.

2) Maintenance of ecological balance. Increase of area under tree cover provides shelter for insectivorous birds, in addition to providing various wood products.

3) Trees provide comfort to travellers on hot sunny days. Tree shade is most invigorating. For this purpose trees with thick foliage are most desirable.

4) Trees on the roads act as noise abators. Excessive noise is one form of environmental pollution. This factor has gained much importance due to high increase in traffic and due to industrialisation. Vehicular traffic on a busy national highway generates a sound intensity of about 72 to 78 decibels, a beeping horn up to 110 decibels, and a screaming jet more than 140 decibels. Sound levels of above 50 decibels are irritable and above 130 decibels are harmful. Trees and shrubs along the roads will reduce the effect of sound. A 30 metres wide tree cover can absorb 6 to 8 decibels of sound intensity. However, this depends on the width, height and density of the belts. To reduce truck noise a belt of 20 to 30 metres wide and for car noise 7 to 8 metres wide belts can be raised. In case of roads on hills, a belt on the uphill will be more beneficial.

5) Aesthetic value of the roads: If the species selected produce coloured flowers and are of good foliage, they add to the beauty of the road. This sort of planning is called bioaesthetic planning.

6) Lastly a belt of trees along the roads helps in camouflaging the traffic, which in war times is of great importance.

Types of Roads

We have several categories of roads.

a) *Main roads*: National highways, state highways and major district roads. The tree line in case of these roads should be 8 to 10 metres away from the centre of the road.

Sissoo (*Dalbergia sissoo*) is the best species for these roads. However, species should be selected according to the soil, terrain and climate of the locality. To improve aesthetics flowering trees also should be planted. In saline areas, *Acacia arabica* and salt tolerant species such as *Terminalia arjuna*, *Albizzia leb-*

bek, Neem, etc. can be planted.

b) *Minor district roads*: One to three rows can be planted about 8 metres from the centre of the road. On these roads cattle damage is the main problem, although fencing is being done in many places. It is better to select species which are not eaten by cattle.

c) *Link roads:* These are very narrow, rarely exceeding 12 metres in width. Here also it is better to plant hardy species.

In bioaesthetic planning, ornamental tree planting should be intensive near level-crossings, bus stands, rest houses, near townships, canal and road crossings, temples, churches, etc. The species recommended are *Delonix regia*, *Cassia fistula*, *Erythrina indica*, *Lagerstroemia* species, shrubs like *Nericeus*, *Hibiscus*, *Bougainvillea*, etc.—these will be aesthetically pleasing to city dwellers.

The following are the main criteria for selection of trees for planting along roads of all types.

a) Quick growing and shade giving trees to be selected.

b) Timber/fruit trees to be selected.

c) Hardy, so as to have good endurance and easy recuperative power, since much damage is likely to trees by travellers and other agencies.

d) Collectively the species should add to the aesthetic value of the road.

e) The trees must be deep-rooted, otherwise in periods of heavy wind, they are likely to be uprooted and block the traffic.

f) Dust absorbers—such as tamarind and other species with small compound leaf should be preferred.

The species selected should be preferably evergreen with clean and straight trunk up to 4 or 5 m in height, otherwise they will obstruct the traffic.

A mixture of species will be unsightly, therefore, pure avenues of one species in some length which provide a better skyline, should be aimed at. The species recommended are (particularly for highways): *Ailanthus excelsa*, *Albizzia procera*, *Alstonia scholaris*, *Azadirechta indica*, *Tamarindus indica*, *Eugenia jambolana*, *Bassia latifolia*, *Sissoo*, *Ficus infectoria*, *Ficus retusa*, *Mangifera indica*, etc.

Afforestation of Foreshore Areas of Major and Minor Irrigation Tanks and Projects and Ponds in Dry Farming Areas

In construction of new irrigation and power projects large extents of tree growth are felled. Large areas are dug up to collect earth for raising bunds, that is, quarry and burrow pits are extensively exploited. Generally in all such places the top soil is removed and rocks get exposed. Such areas should be afforested by hardy species. Species such as Eucalyptus, *Acacias*, Neem and *Albizzias*. In heavy rainfall zones Teak, Mahogony, Mango, *Ailanthus*, *Cassia siamea* and Bamboo can be planted.

If the catchments of these projects are bare, as is the case in many of our projects, the areas should be contour trenched and afforested to prevent the reservoirs from silting up. In fact the afforestation of the catchment should form part of the project cost.

In the foreshores of the minor projects and tanks, etc., the government had some time ago, permitted cultivation by weaker sections. This had added to the silting speed of the tanks and reservoirs. Again, an exposed tank, spread over extensive areas, is badly affected by evaporation of water. Ideally we should have small deep tanks that are well surrounded by trees.

On the belt above the maximum water level contour trenching will prevent silting and on the mounds and in the trenches trees and shrubs can be raised. In the tank bed itself, species of *Acacias* can be planted which withstand submergence for quite some time.

Reclamation

This practice is employed when lands become uncultivable. Such lands may be bare or eroded lands, swampy areas, alkaline areas amidst cultivation, sandy wastes, laterite soils not suitable for cultivation. For each type of land the preparation methods and techniques vary. These operations are also called preliminary operations. In case of bare areas, which are flat without any tree vegetation or stones, etc., a mere ploughing and digging of pits is enough. Planting is done in the pits.

In eroded areas, the slopes should be eased out on the gully heads and trenches dug along the contours and when mounds are formed and planting done in the trench and on the mound.

Gully plugging is carried out by masonry constructions or by brushwood. In the gullies, agave, bamboos, grasses, *Cassia siamea*, *Albizzia lebbek*, etc., can be planted. The water courses in such eroded areas are trained by planting *Vitex alttissima*, *Arundo donax*, etc.

For swampy areas the method is to drain off the water by digging trenches in the form of a herring bone, and species which come up in swamps should be planted. They are *Lagerstroemia flosreginae*, *Eucalyptus rostrata*, *Bischoffia javanica*, *Salix tetrasperma*, *Eugenia jambolana*, *Terminalia tomentosa* etc. For planting or sowing, ridges and mounds should be formed.

In alkaline soils also, trenches should be dug to drain off the salts and mounds or ridges formed on which sowing of seeds of *Acacia arabica* and *Agave* planting is carried out.

In sandy wastes the water retention is poor. Therefore, planting bricks are employed. These bricks are formed with a soil mixture of red earth, sand and clay or silt. Seedlings are planted on the bricks and are then transported to the site where pits of 45 cm cube are dug up and brick plants planted.

Another commonly employed method is to plant seedlings raised in polythene bags.

The species preferred are *Casuariana*, *Anacardium occidentale*, *Pongamia glabra*. In addition, species which bind the soil and sand are planted and for this purpose *Ipomea bioloba* is recommended.

For laterite soils the only method is to dig up pits and plant. Pits of 45 cm cube are formed and polythene bag plants of cashew, mahogany, *Xylia xylocarpa*, Neem and *Ficus* cuttings are planted.

We have one or the other type of land in all our villages. If these are covered with vegetation and tree crops, the economy of the people will be enriched.

Urban Planting

Conditions in urban areas are different from rural areas. Here we come across huge structures of stone and cement, which radiate heat. Urban areas are affected by smoke, noise and dust, whose adverse effect cannot be easily estimated. Pollution of air and water due to exhaust fumes is considerable. Tree vegetation, which reduces pollution, should be planted.

Further difficulties in planning tree planting are created by the narrow paths and roads, overhead telephone and power lines. The problem here is to find space. Therefore, tree planting should be done wherever conditions are favourable and suitable. It is better to select tall narrow crowned trees, which can withstand heat, but should be shady. In all the localities, wherever colonies are formed or where small bits of land are available, it is better to form small parks. Landscaping if practised diligently will add to the aesthetics of the locality.

Species recommended are *Cassias*, *Peltophorum*, *Polyalthia*, *Delonix*, *Spathodea*, *Enterolobeum*, *Plumerias*, *Ficus*, *Mango*, *Eugenia*, *Jacaranda*, etc.

Amenity Planting

In addition to the above, we should have trees and shrubs planted in other public and private premises wherever space is available in the following:

1) Public buildings, schools, colleges, hospitals, offices, etc.
2) Monumental and historical gardens.
3) Crematoriums, cemetry and burial grounds.
4) Industrial areas.
5) Home gardens.

The above social forestry practices will benefit the society in the following manner:

Benefits of Social Forestry

1) Betterment of environment.
2) Reduction of pollution.
3) Providing the basic needs of rural and urban people for fuel, small timber, manure leaf and other economic products nearer home.
4) Providing raw materials for industries such as wood, wool, packing cases, slate frames, sisal fibre, tamarind extract, oil seeds, pulping and hutting material.
5) Provide shelter for insectivorous birds in the farms.
6) Protection from wind.
7) Conservation of moisture.
8) Prevention of soil erosion.
9) Fuller utilisation of land unsuitable for cultivation.
10) Employment opportunities in rural and urban areas.

11) Reduction of noise.
12) Recreation.
13) Reduction of pressure on national forests.
14) Achievement of self-sufficiency by the villages.
15) Improvement of rainfall by inducing precipitation.

CHAPTER 7

MANAGEMENT AND HARVESTING OF FOREST PRODUCE

Forests are managed for sustained yield under various systems of management. Selection system, clear felling system, coppice with reserve system, simple coppice, shelter wood system and so on.

In case of forests raised under Social Forestry the management practices differ considerably. They are decided by and based on the objects of raising wood lots according to each social forestry practice. It can be for small timber, fuel wood, usufruct, oilseeds, leaf manure or only for protective purposes. Therefore, the following are some indications for managing and harvesting the tree lands raised under social forestry practices:

Small timber: Trees and shrubs, 30 to 40 years old, which produce 1 to 1.5 m girth at 1.5 m height are enough for this purpose. At that time either poles are selected and felled or coppice system is followed or the entire block felled and replanted.

Fuel wood: Trees can be felled at a shorter rotation of eight to ten years, and if the plants are watered, even earlier. Generally Eucalyptus and Casuariana raised are clear felled. The stumps or stools of Eucalyptus are dressed to give coppice shoots and Casuariana which is a poor coppicer is replanted after felling.

Usufructs and oilseeds: Only physical rotation is followed. Here trees are not felled; only the right to collect the fruits, etc. is leased or the fruits are collected and sold.

Leaf manure: Manure leaf consists of fallen leaves and flowers or lopped branches. It is added to the paddy fields, etc. Manuring can be with or without composting. The method of harvesting the leaf should be such that it does not kill the tree or restrict its growth. Removal of leaf or topping for manure leaves should be done once or twice a year before or after collection of its usufructs. Normally one-third of the crown is left intact and lopping or pruning is done up to two-thirds of the height of the tree. Only when trees are crooked, malformed or dead, should they be felled.

Protection: All the trees grown to protect the river courses, tanks and to prevent erosion, etc. are never cut or disturbed except to collect their fruits.

Marketing: Marketing can be by way of auction to public agencies or by owner agencies collecting and selling the produce. The second method has become very popular as better control on the techniques can be exercised.

Protection of Planted Area

The agencies which are likely to cause damage to the trees and other plantations raised under social forestry are:

1) Cattle, sheep and goats by grazing and browsing.

2) Men by theft and damage with mischievous intentions.

3) Fires started by men either purposely or accidentally. Many species are fire hardy, that is, they can withstand fire damage to some extent. Many species can not withstand fire damage at all, they get scorched or killed.

4) Rodents, rats and rabbits, etc., that dig out roots or destroy the fruit and seed.

To protect trees from grazing and browsing, fencing has to be provided.

Fences can be of live hedges of thorny species like Agave, *Acacias*, etc. A mound is formed all round the plant and Agave *bulbils* or suckers planted.

1) A cattle proof trench is dug up round the area or the plant. This consists of a 1.5. m wide and 1.5 m deep trench which cannot be negotiated by cattle. The disadvantage in this method is that in hard soil it is difficult to dig the trenches and they are likely to silt up. In places where small streams come across, digging of a trench is difficult and unsuitable.

2) Brushwood fences consist of construction of a thick (about 0.5 to 1.0 m and about 1.5 to 2 m high) heap of thorny material and other brushwood around the area. The draw-

back in this is, that they are likely to be blown away by the wind or burnt by accidental fires or in wilful incendiarism.

Barbed wire fence: A fence of three to five strand barbed wire can be fixed all round. The stays can be of poles or posts, stone monoliths and angle iron.

Although the last one is costly, it is better than the above two methods.

As a protection against rodents and porcupines which easily jump over a high fence; the fence is raised with a bottom of 0.5 m high woven wire or hexagonal mesh.

Protection from rats and rodents also can be achieved by using cynogas, barium carbonate in wheat flour, etc.

Protection from theft by man is achieved only through vigilance.

Protection from fire is achieved by removing the dried grass, leaves, etc., by scraping to a distance of 1 to 1.5 m all round the plant or 4 m all round the area. This operation, called fire tracing, is commonly taken up in February, since fire damage is more common during summer.

CHAPTER 8

RECREATIONAL FORESTRY AND NATIONAL FOREST POLICY

The practice of going to forests for picnics or for *Vana Bhojana* is very old. This is a very healthy practice as it brings us closer to nature and relieves us from the day to day stresses and strains of life. It is common to see people collecting even under small grooves and avenue trees along the roadsides for picnics. In most of the cities and villages there are no such picnic spots nor any forest area. It is, therefore, a social obligation that for every village, town and city such recreational avenues be created.

These can be picnic corners, camping sites, public gardens, zoos, etc. They need a good amount of planning to see that all such picnic and recreational forests have water facilities, sufficient private nooks, waste disposal arrangements, etc. The areas should be planted with shade bearing and fruit bearing trees and flowering shrubs.

The National Commission on Agriculture has recommended that each state should make a study of the problems of recreational needs of the urban areas and dedicate some forests or establish tree grooves near such areas. It also recommended provision of Rs. 10 crores in the Fifth Plan in the state sector.

Wildlife Conservation

Wildlife is defined as the entire native uncultivated flora and fauna of the country.

Despite lack of scientific management, India is still very rich in a variety of wildlife. This country has a large number of representatives of both the Asian and the European species. There are eight species of deer and more varieties of cats than in any other country. Several varieties of wild goats, the Asiatic lion, the one-horned Rhinoceros, the Indian elephant, the wild Gaur (Bison), wild buffaloes, bears, boars, etc., are found in the forests of India.

Most of the wildlife is threatened with extinction due to indiscriminate hunting, snaring, etc. The tiger population which at one time was over 1 lakh in number has dwindled to hardly 4,000. The population of wildlife is critical except in national parks, sanctuaries and closed areas.

Past history shows that wildlife has been destroyed by the rulers and their armies or indirectly by the ruthless destruction of the habitat.

The over-exploitation of the forests during the Second World War accelerated the destruction of the habitat of wildlife. Use of fast moving vehicles particularly jeeps with search lights for hunting is one main cause for the destruction of wildlife. Another agency was the crop protection guns issued indiscriminately in the villages. Tigers and lions were poisoned by the villagers by dressing their kills with Endrin.

The species which are extinct or threatened with extinction are the hunting cheetah, the pigmy hog, the hispid hare, the white winged wood duck, the dugong, the wild ass, the fishing cat. the marbled cat, the caracal, the clouded leopard, etc. Thus, there are 38 species which are threatened with extinction and 14 bird species and two reptiles which are on the way to extinction.

To preserve wildlife and also to create interest in wildlife preservation, five National Parks and 126 Wildlife Sanctuaries have been created in the country and another 40 sanctuaries are planned to be formed.

The objects in forming these parks and sanctuaries are:

i) Preservation of fauna and flora;
ii) Prevention of extinction of fauna; and
iii) Protection of animals threatened with extinction.

National parks are established by an Act of the Parliament. A national park is an extensive one and the area is divided into two or three parts. The outermost is a buffer zone, second comes the cruise area, where forestry operations are permitted and the third is the sanctum sanctorum where no operations are permitted. In wildlife sanctuaries, we have only two belts, the buffer zone and the sanctum sanctorum. These national parks and sanctuaries attract a good number of foreign and local tourists and earn lot of foreign exchange. They are provided with all facilities for camping, etc.

In these parks and sanctuaries, the wildlife is well looked after. Their need for privacy, water and salt licks are provided. They are protected from communicable diseases such as Rinderpest, etc.

Project Tiger

Between First and Second World Wars, the population of tigers in the forests of India was over 40,000. With the waging of war and the introduction of jeeps fitted with powerful searchlights, etc., poaching increased tremendously. The tiger was the first target of destruction. The present tiger population is about 4,000 only and its habitat also is considerably decreased. To preserve this species from extinction world opinion has crystallised and Project Tiger has been formulated which is financed by the World Wildlife Fund. This fund is created with donations from many nations. More than a crore of rupees are expected to be spent to preserve and enrich the tiger population by protecting its habitat and increasing its prey.

National Forest Policy of India

Development of forests is expected to follow the policies adopted for management of the forests in the country. Before independence, India already had a National Forest Policy enunciated in 1894. This policy laid down that:

1) Forests on hill slopes should be protected;

2) Forests should be managed on commercial lines;

3) Wherever cultivable land exists in the forests, it should be brought under cultivation, subject to condition that "honeycombing" of a valuable forest should not be allowed and that the cultivation should be permanent.

4) Forests of superior type should be raised for the benefit of local people.

This policy was more inclined towards the development of agriculture.

After Independence it was considered necessary to revise the forest policy, in view of the revolutionary changes which had taken place. The 1894 policy was revised in 1952. This policy proposed the classification of forests on a functional basis. It emphasised that the widely entertained notion that had to be combated was that forestry as such has no intrinsic right to land but may be permitted on sufferance on residual land not required for any other purpose.

The National Forest Policy had laid stress on creating tree lands and maintain 60 per cent of the hills and 20 per cent of the plains under forests.

None of the recommendations of the policy were implemented and no legislation to that effect introduced.

Even before the issue of the National Forest Policy, a Central Board of Forestry was created in 1950, to watch the progress and give guidance to the Government in formulation of the policy.

Since the enunciation of the National Forest Policy in 1952, developments of far reaching importance have taken place in the economic, social and political fields. The Central Board of Forestry recommended the creation of a commission to study and recommend the basis for a revised National Forest Policy. The commission published its report in 1976, which is under consideration and based on its report the National Forest Policy will be re-enunciated.

The commission has recommended that the National Forest Policy should be based on the following important needs of the country.

1) Managing the forest resources of the country so as to provide maximum goods and service for the well-being of the people and economic progress of the country.

2) Checking denudation and erosion in mountainous regions and catchments of rivers on which depend perennial stream flows, fertility of the land in the catchments and the useful life of dams and reservoirs.

3) Preventing erosion along treeless banks of rivers and on the vast stretches of waste lands, and arresting the spread of sea sand on coastal tracts and of shifting sand dunes in the western desert.

4) Maximising the forest productivity with a view to meeting the growing demand for industrial raw materials, timber and other forest produce for defence, communications and domestic needs and to augment employment potential, with the ultimate

aim of national prosperity.

5) Providing small timber and fuel wood requirements of the rural population.

6) Providing grass and grazing for livestock in forest areas, ensuring that it is not harmful to the forests.

7) Providing recreational and tourist opportunities in the forest without impairment of forest resources including wildlife and preservation of environmental balance.

8) Creating blocks of forests interspersed with cultivation or by introducing trees in larger numbers in the ecosystem, after careful selection, for maintaining a healthy relationship between soil, vegetation and animal life and establishing diverse biotic complexes for elimination of natural enemies of insects and other pests which damage crop monoculture.

The commission has stressed that no deforestation should be permitted without the approval of the State Legislature.

The recommendations of the commission are already being implemented in many aspects.

CHAPTER 9

WATER—ITS RECEIPT AND MANAGEMENT

A photograph of the Osmansagar locally called "Gandipet", with stony out crops, appeared in *The Hindu* in February 1983. It was said that another reservoir, Himayatsagar, also presented a similar grave picture. These two reservoirs are the main source of water supply to a vast population of 3 million in the twin cities of Hyderabad and Secunderabad.

Some years back, the big Krishnaraja Sagar reservoir in Mysore was totally empty; around the same time, the Nizamsagar in Andhra Pradesh was also dry. A reservoir getting dry is like bankruptcy in a bank with the difference that there is no scope for overdraft of water.

As an analogy, a Chairman of a bank has to be prudent enough and look to the coffers which have to remain full all the time, if he has to succeed, in the profession of banking. To this end he has to ensure that the inflow of funds are continuous by way of deposits, and should further ensure that nothing is wasted.

Unfortunately, water, which is indirect money, is being managed in a very cavalier manner and losses due to several elements are not being plugged.

All the reservoirs have their source in a stream or river, the inflow or deposit of water is this source only. But even before the deposit starts flowing in, it is lost due to several elements. Most of the big reservoirs in the south, have streams and rivers which originate in the Western Ghats or in the Nilgiris. After they leave this vast catchment, these rivers flow through plains with almost no forested land or through heavily damaged low hilly tracts.

Now, to have a reservoir with sufficient water stored in it the inflow has to be also continuous. What actually happens is that there is a spurt of water flowing into these tanks during the four to five months of monsoon season, and thereafter the inflow is negligible. That is, when the river system itself becomes dry, the long gap between the cessation of rains and the onset of the next monsoon, takes toll of the reservoir, which faces a period when it becomes dry, as has happened to the various reservoirs at one time or the other. It is significant to see that *The Hindu* publishes the water depth in the reservoirs as if announcing the cash balances to the depositor in a bank.

Having established the importance of a reservoir let us turn to the river systems and their tributaries. These are no more perennial; they are being robbed of their wealth of water during their long journey through the plains. Not only are the rivers and streams emptied even before they reach the tanks, but as a snub are fed with all sorts of waste, debris, silt and sand. The lack of proper management of lands existing on either side of these rivers once they come into the plains has effected very adversely the flow of water. It is firstly neglected at the source itself, as the catchments in the Western Ghats and low hilly tracts in the plains, are put to withstand heavy assaults on their vegetation cover by the people in and around the catchment, and secondly when the river comes into the plains the poor land management of the fields aggravates the already spoilt system.

A river to be perennial has to be deep and narrow to reduce evaporation losses; should flow with as low a velocity as the terrain can permit, its banks should be smooth and withstand the force of the water flow without giving up its base and without allowing the soil to drop in the bed of the river. The excess rain water flowing from the fields into the river should be clean, and should not bring with it the soil and debris of agricultural waste, into the river flow.

To achieve the above objective a correct scientific river and stream management system should be followed. The main features of this system are: (1) to control the sheet and rill erosion in the fields by soil conservation bunds, by gully plugging the low ravines and by check dams to reduce the water velocity, (2) to protect the banks of the rivers and streams from caving in and dumping mud rocks in the river beds they should be smoothed and banks given a gentle slope or stone revetments built, wherever the soil is loose and liable to wash off, (3) to reduce evaporation losses of the flowing water of these rivers, a canopy of tree crowns should be provided, by planting multiple rows of trees on banks on either side of the river, (4) to reduce the velocity and increase the depth of the rivers and streams, spurs with rough stone or masonry construction at obtuse angles to the banks of the river should be constructed. These will train the water to flow in the river in a narrow and deep course, in the centre of the river beds, (5) punitive action should be imposed on all who treat the rivers as a drain for their refuse.

The above steps, clubbed with scientific and proper management of the catchments, will definitely revive the perenniality of our rivers and streams. For the main catchment areas, the hills and mountains which exist at the source of the rivers and streams, soil and moisture conservation measures will have to be adopted. All the tracts should be covered with gully pluggings, check dams and small reservoirs to arrest the inflow of silt into the rivers.

The problem of drinking water has become acute in the recent past, because of the neglect exercised in management of the water flow. We spend fortunes to dig wells, drive bore wells and run fleets of tankers to take water to the needy. If the rivers, streams and reservoirs remain dry, no amount of open or bore wells can solve the problem of water scarcity. After all these wells get water only from the streams and rivers due to seepage under the sub-soil. Instead of the yearly exercise to fight water scarcity, we should think of solving it by removing the impediments at the source itself that makes the rivers and streams perennial.

The above measures are multifaceted as they will also solve the problems of drought, floods and diseases.

CHAPTER 10

WOOD-BASED INDUSTRIES

The wood-based industries can be classified as heavy industries and small-scale or cottage industries. Among the heavy industries, the following are included:

1. Paper and pulp
2. Rayon grade pulp
3. Plywood
4. Particle board
5. Fibre boards
6. Veneers
7. Railway sleepers
8. Defence products
9. For lorries and bus bodies
10. Match industry
11. Building construction (Saw milling)
12. Distilleries.

Among the small-scale or cottage industries, the following can be included:

1. Sawn timber
2. Toys and art pieces
3. Slate frames
4. Packing cases
5. Agricultural implements
6. Small saw mills
7. Charcoal manufacture
8. Furniture
9. Bamboo mats
10. Pit props
11. Scaffolding
12. Post & telegraph poles
13. Electricity transmission lines

Industries which depend on minor forest products are:

1. Beedi manufacture
2. Gums and resins
3. Tanning materials i.e. myrobolans, barks of trees
4. *Katha* industry
5. Fibres and flosses
6. Honey and wax
7. Grass ropes
8. Brooms
9. Liquor from mohwa flowers
10. Non-essential oils from mohwa and karanj seeds
11. Perfumery i.e., sandalwood oils, rosa oil

12. Collection and processing of seeds of buchanania i.e., karanj, walnuts.
13. Sericulture, lac production, etc.

The following timbers and their products are exported:

1. Rose wood (*Dalbergia latifolia*).
2. Teak wood (*Tectona grandis*).
3. Red sanders (*Pterocarpus santalinus*).
4. Sandal wood and its products (*Santalum album*).

All the above industries provide a highly profitable employment avenues and the revenue earned adds to the Gross National Product.

The total requirement of industrial wood was estimated at 25 million cubic metre by 1980 and 40 million cubic metres by 1990. The requirement of bamboo for paper and pulp was estimated at 0.9 million tonnes by 1980 and 60 million tonnes by 1990.

The fuel wood requirement by 1980 was estimated at 184 million cubic metres and by 1990 it is likely to be 225 million cubic metres. To this, if we add about 60 to 70 million tonnes of fuel wood to be used to replace roughly 400 million tonnes of cowdung being burnt, the total fuel wood requirement will be very high. As recommended by the National Forest Policy, the national forests are to be totally diverted to meet the demand for industrial wood, therefore, a major part of fuelwood requirement will have to be met by the tree lands and forests raised under social forestry programmes.

The above figures show the need and necessity to implement successfully the social forestry programmes.

Labour Potential

Forests are an important source of employment in the rural areas. The employment offered in this sector is often in the off season for crop production and is, therefore, complementary to the employment in farm production. For instance, logging is generally carried out in the lean agricultural months. Secondly, as forests are located in backward areas, direct employment in forestry activities can benefit the backward communities, such as tribals. Further, activities in the forestry sector require a very high component of unskilled labour; therefore, this will benefit the unemployed and under-employed agricultural labourers of weaker sections of the rural community.

The agricultural labour in summer, when there is little or no work in their fields, can be employed in collection, processing and grading, etc. of minor forest produce. The present employment provided in all forestry operations is about 2 to 3 million man years and by 2000 A.D. it will be of the order of 5.5 million man years.

Wood as a General Utility Material

Almost every part of a tree can be used for various purposes. Wood in various forms follows us from the cradle to the grave. Although many synthetic products are replacing wood and its derivatives, their costs are rising and they need a lot of import substitutes. If wood production is improved by social forestry programmes, there is every likelihood of a reduction in imports and expanding exports.

Timber Seasoning

Timber both in the form of logs and sawn sizes needs to be preserved for a long time. Wood is a poor conductor of heat. It absorbs moisture and expands and with heat the moisture in the wood evaporates and it shrinks. In this process of expansion and contraction, wood changes its colour and shape. Seasoning of wood is a process to stabilise the moisture content in the wood. In the case of doors and windows and furniture, the wood used, if not seasoned, will lead to a situation where the shutters of the doors and windows do not close properly or get jammed. Therefore, it is essential that for all purposes only seasoned wood is used, more so for building construction and furniture.

There are principally three methods of seasoning wood:

i) Immersion method; (ii) Air seasoning; and (iii) Mechanical seasoning.

Immersion method: This method involves storage of timber, mostly logs, in a pond full of water. Logs if stored in the open, tend to develop surface cracks and sectional cracks, in their process of loosing the stored moisture. By storing the logs under water, the development of cracks can be prevented. Some timber logs of species such as *Terminalias*, *Annogeissus*, *Diospyros*, *Chloroxylon*, *Hardwickia*, etc. develop such cracks very early during storage.

Teak being a close grained timber, the development of cracks is not severe. However, the ends of the logs are likely to develop a variety of splits and cracks. To prevent this, a paste of red earth is generally applied to the end surfaces.

Air seasoning: This is a method to season the sawn timber by storage in the open. This consists of arranging the sawn sizes in the form of a crib, alternating the layers in direction, leaving sufficient inter-space for air circulation. The stack so formed is placed in shade and a thin layer of sand spread over the top layer. Storage in this fashion for a couple of months will season the sawn sizes.

Mechanical seasoning: This involves removal of moisture under pressure in a mechanical chamber. The sawn sizes are stacked in the seasoning chamber for about 24 hours under a given pressure so that the moisture in the timber gets stabilised. We have very few such seasoning plants in our country.

Wood lasts longer and maintains its strength with seasoning and treatment with preservatives. Adoption of these methods for non-conventional woods will improve the economics of timber trade. For example *Chloroxylon swietenia* and *Terminalia tomentosa* which are not used in building construction, can be treated and seasoned and used in place of the conventioal teak wood or salwood.

Wood Preservation

Wood preservation implies application of chemical processes to make it last longer. Wood has several pests in its dry form, and termite damage is the heaviest. Treatment with preservatives reduces this damage. There are two important methods of preservation:

(i) Creosote treatment, and (ii) Ascu treatment.

The first method is applied for heavy timber such as railway sleepers and shipmasts, etc. The second method is for small timber. In the first method, the Creosote oil is impregnated into the wood and in the second method Ascu solution which consists of copper sulphate is used for impregnation.

Railway sleepers, etc., of coniferous wood are treated with Creosote oil. The sleepers are first run through a mill which drives holes in the wood and then they are dipped in Creosote oil (a derivative from coal tar) tanks.

Bamboos and small timbers are dipped in tanks containing the "Ascu" solution.

However, the methods of preservation are not widely employed in sub-tropical regions.

CHAPTER 11

SPECIES FOR SOCIAL FORESTRY

Choice of Species

For the practice of Social Forestry programmes, the species to be raised, depend on several aspects. However, climatic and edaphic factors restrict our choice. The species useful for various programmes are already detailed. However, the following is the list of species which are commonly used for social forestry purposes.

Botanical name	*Family*
1. *Acacia arabica*	Mimosoidae
2. *Acacia catechu*	Mimosoidae
3. *Acacia concianna*	Mimosoidae
4. *Albizzia lebbek*	Mimosoidae
5. *Albizzia procera*	Mimosoidae
6. *Alstonia scholaris*	Apocynaceae
7. *Adina cordifolia*	Rubiaceae
8. *Ailanthus excelsa*	Simarubaceae
9. *Artocarpus hirsuta*	Moraceae
10. *Azadirechta indica*	Meliaceae
11. *Anacardium occidentale*	Anacardiaceae
12. *Acrocarpus fraxinifolius*	Caesalpinae
13. *Bauhinia variegata*	Caesalpinae
14. *Bambusa arundinacea*	Graminae
15. *Bombax malabaricum*	Bombacaceae
16. *Butea monosperma*	Leguminosae
17. *Cassia siamea*	Caesalpinae
18. *Cassia renigera*	Caesalpinae
19. *Cassia javanica*	Caesalpinae
20. *Casuariana equisitifolia*	Casuarinacae
21. *Cedrela toona*	Meliaceae

Botanical name	*Family*
22. *Dalbergia sissoo*	Leguminosae
23. *Dalbergia latifolia*	Leguminosae
24. *Dendrocalamus strictus*	Graminae
25. *Delonix regia*	Caesalpinae
26. *Dudonea viscosa*	Sapindaceae
27. *Duranta plumeria*	Verbenaceae
28. *Emblica officinalis*	Euphorbiacea
29. *Enterolobium saman*	Mimosoidae
30. *Eucalyptus* species	Myrtaceae
31. *Eugenia jambolana*	Myrtaceae
32. *Feronia elephantum*	Rutaceae
33. *Ficus* spp.	Moraceae
34. *Glyricidia maculata*	Leguminosae
35. *Gmelina arborea*	Verbenaceae
36. *Grevillia robusta*	Porteaceae
37. *Hardwickia binata*	Caesalpinae
38. *Holoptelea integrifolia*	Ulmaceae
39. *Jacaranda mimosaefolia*	Bignoniaceae
40. *Lannea grandis*	Anacardiaceae
41. *Lagerstroemia flosreginae*	Lythraceae
42. *Mangifera indica*	Anacardiaceae
43. *Melia azadirechta*	Meliaceae
44. *Moringa pterygosperma*	Moringaceae
45. *Madhuca latifolia*	Sapotaceae
46. *Murraya* spp.	Rutaceae
47. *Ougenia dalbergioides*	Leguminosae
48. *Peltophorum ferrugineum*	Caesalpinae
49. *Prosopis juliflora*	Mimosoidae
50. *Pongamia glabra*	Leguminosae
51. *Polyalthia* spp.	Anonncea
52. *Pithecolobium dulce*	Mimosoidae
53. *Santalum album*	Santalaceae
54. *Sapindus emarginatus*	Sapindaceae
55. *Sesbania grandiflora*	Leguminosae
56. *Sesbania aegyptica*	Leguminosae
57. *Spondias mangifera*	Anacardiaceae
58. *Tamarindus indica*	Caesalpinae
59. *Tectona grandis*	Verbenaceae

Botanical name	*Family*
60. *Terminalia* spp.	Combretaceae
61. *Thespesia populnea*	Malvaceae
62. *Tecoma* spp.	Bignonaceae
63. *Vitex negundo*	Verbenaceae
64. *Wrightia tinctoria*	Apocynaceae
65. *Zizyphus jujuba*	Rhamnaceae

Almost all the species listed above are useful either for shade, aesthetic value, fruits or for fuel and timber.

Social forestry practices are for only subsidiary requirements and are performed to fulfil many of our needs, the economics of the practices take a secondary place. For instance, avenues, wind breaks and shelter belts, are raised to meet a specific purpose. Therefore, the cost of their raising and maintenance should not ordinarily be considered as an investment that will have returns. In such cases the returns are indirect.

In forestry operations where block planting is carried out, no irrigation is done. It is only in very few instances that irrigation is resorted to. Even there, the returns are expected to flow fast and are commensurate with the investment.

The inputs vary according to the site, species, nursery and planting methods. It is difficult, therefore, to standardise the economics of social forestry practices.

The direct and indirect benefits from tree vegetation far outweigh the inputs. Therefore, no detailed economic calculations are attempted.

CHAPTER 12

METHODS OF RAISING TREES

Tree lands or forests can be created by several methods:

1) Sowing of seeds on prepared sites.

2) Planting of root and shoot cuttings (stumps) in crow bar holes.

3) Planting of polythene bag plants in pits or on mounds.

4) Planting pot plants in pits or on mounds.

5) Planting of bricks with plants raised in them preferred for heavy sandy soils.

6) Planting of large sized plants raised in drums.

7) Planting naked seedlings.

8) Planting seedlings with a ball of earth.

The method suitable, for species to be raised and site to be planted, should be followed.

Types of Land

In general, social forestry operations will encounter badly cut up and eroded lands. The cardinal principle before afforesing any of these lands is to conserve the available soil and moisture on the site. The following are some of the techniques commonly applicable to the practices of social forestry:

1) In flat areas, mere pitting is sufficient.

2) In gently sloping areas, staggered trenches should be dug up and sowing or planting done in the trench or on the mound formed towards the sloping side.

3) In heavily eroded sites, the slopes should be eased and the gullies plugged then staggered trenches dug up and planted.

4) In a hill slope, contour trenches should be dug up and mounds formed on the sloping side, seeds or plants introduced in the trenches and on the mounds.

5) In waterlogged and marshy areas, the water should be

drained out by shallow trenches in a herring bone pattern and seedlings planted.

6) In sandy and coastal areas planting bricks should be used to raise tree lands.

7) In desert sands and on mobile sand dunes, the sand dunes should be first consolidated by spreading leaf litter or brush wood and seedlings raised in bags, pots or bricks planted.

Generally trees on farm lands are planted before the crop sowing is done, so that the plants get established by the time the farm operations start. This will prevent damage to the seedling during sowing of crops and other operations.

When the trees are to be harvested, it is best done when there is no crop on the fields.

Very few species are hardy and resist attack by insect pests and fungus diseases. Termites, grubs and ants damage the roots and treatment with insecticides and sterilisation of the planting site is recommended. The commonly used insecticide is BHC 10 per cent dust or solution.

Grass hoppers and larvae which skelatonise the leaves and defoliate the plants can be controlled by spraying insecticides.

Fungal damage of roots of Acacias, Ailanthus and Bamboo are also common and they are controlled by using fungicides before planting.

Fungal attack on the leaves of seedlings is rare and many recover from the attack. However, syraying of seedlings with fungicides or dipping the seedlings in a solution before planting is practiced.

Damping off, that is, excessive water in the soil reverses the osmosis in the roots. This can be rectified by application of a dilute solution of copper sulphate.

General Principles of Nursery Management

The planting stock required is raised in the nursery. The principle is that a well grown seedling conditioned and reared in the nursery will be in a better position to resist the extremes of field conditions.

The nursery should be generally as near to the planting site as possible and seedlings raised for about one to two years in a nursery are planted out.

The site for the nursery should have good water supply and shade for some of the species.

The seedlings raised should be hardened by stopping irrigation and watering for a couple of days before planting. After transporting the seedlings to the sites the seedlings should be allowed time to recover from the shock of transport for a day.

Seasons of Planting

Planting seasons vary with the species and the commencement of the monsoon. Teak, Red sanders and Sissoo stumps are planted with the commencement of rains. Casuariana, Eucalyptus and other pot culture plants are planted after the monsoon sets in and is advanced to some extent. In the east-coast where the northeast monsoon is dependable, planting is done in September or October. In areas of the southwest the monsoon is during June/July.

Field Preparation

The area to be planted has to be prepared before planting is taken up. In block plantings, the site is cleared of all the bushes and useless growth in February/March and the debris burnt. The planting points are staked out and pits or trenches dug up by end of April. The soil thus dug up is allowed to weather for a couple of months before planting.

Even in case of plantings on road sides and canal banks, etc., the pits should be dug in May/June, the soil allowed to weather and then seedlings planted.

For Teak, Sissoo, Red sanders and Eucalyptus the site is burnt well with the available debris or by spreading debris brought from outside, to sterilise the site and to reduce weed growth.

Planting

All the planting stock, either stumps or bag plants or pot plants, should be ready at the planting site a couple of days before planting. In case of stumps, that is root and shoot cuttings, the planting is done in crow bar holes. The operation is best done when the soil is slightly moist for the crow bar to make a hole. The stump is placed in the hole and pressed from all sides, so that no air space is left around, otherwise the stumps rot. The stumps are planted flush with the ground to prevent their drying.

In case of bag plants and pot plants the polythene cover or the pot is broken carefully, without damaging the seedlings and then the plant with its soil cover placed in the pit and firmly covered.

In case of branch cuttings of Ficus or Boswelia, etc., the cut surface is covered with a thin layer of moist earth to prevent transpiration loss.

Post-planting Care

This consists of the following operations, after planting:

1) *Irrigation by watering*: For avenue plants, watering is advisable to assure establishment of the plants. In case of block plantings on village lands and in forest areas, it is better to plant a greater number to allow for casualty. In the Forest Department watering is rarely resorted to as it is a very costly operation.

2) *Weedings*: To reduce root competition and suppression of the plants from weeds and grasses, an area of about 1.5 m diameter alround the plant is cleared of weed growth. This operation must be done once in a month.

3) *Soil working*: This involves loosening the soil and working up the soil around the plant to prevent soil moisture loss. The operation should be carried out with all the weedings and particularly when there is a heavy gap in the rains and at the beginning of the hot season. Mulching with twigs and brush wood is also carried out to prevent the soil from hardening.

4) *Fire tracing*: A belt of 2 m diameter on all sides of the plant will prevent any direct damage from fire, if it occurs in the area planted.

In case of block plantings, a fire line of 4 metre width around the area should be cleared so that no fire enters the area.

5) *Singling*: In case of double or more shoots developing on the plant it is advisable to remove all, retaining the best, so that the establishment is quicker and growth is faster.

6) *Pruning*: In the second or third year, if there are any low branches, they should be pruned by a saw or sharp implement without damaging the plant. This will help in better height growth of the plant.

Generally all the plants, with good care, take root in one or two years.

7) *Harvest*: Most of the fuel species, like Casuariana, Eucalyptus, can be harvested in the seventh or eighth year of planting. Small poles and agricultural implements can be obtained from the trees in the twelfth to fifteenth years. Usufructs can be harvested as and when they are ready. In case of pasture and grasses, the best time to harvest is before the setting in of inflorescence.

CHAPTER 13

TREE CROP HUSBANDRY

BAMBOO

There are several species of bamboo, the most important for our regions are two: (i) *Dendrocalamus strictus*, and (ii) *Bambusa arundinacea.* They belong to family Graminae. *Dendrocalamus strictus* is found in well drained sandy loam soils of our forests. The clumps of bamboos contain two or more and up to 50 shoots called 'culms' and are developed annually from the Rhizomes and attain their full size in one season only. The culms are 10 to 15 m in height and of 15 to 20 cm in girth.

In moist localities and along perennial streams, *Bambusa arundinacea* is commonly seen. This is a thick bamboo reaching 15 to 20 m in height, with girths up to 30 to 45 cm.

Flowering

The bamboos flower once in their lifetime and thus are called cyclic flowerers. After their flowering and seeding the clumps dry up. The life of a bamboo plant is about 40 years, but with repeated hacking, over felling and damage due to overgrazing and fire, etc., the flowering can occur much earlier. The general season for flowering is January/February and seed can be collected in March.

Bamboo is a gregarious flowering species, that is in a given bamboo belt, the flowering will spread like an epidemic and all the clumps flower and seed and dry up in a couple of years. However, sporadic flowering is also seen in some years. Another interesting observation is that bamboo flowering is related to droughts and famine. Villagers near about the forests, collect the seed for food. It is also observed that rats and squirrels relish the bamboo seed. Wherever gregarious flowering occurs, rats are seen to multiply as they have plenty of seed for food.

Collection of Seed

The seed which is like wheat grain ripens on the culms and drops to the ground. In about 1 kg there are over 10,000 to 15,000 seeds. When the flowering and development of seeds on the culms is noticed, the ground is cleared of the leaf litter and grasses, etc., and the seed dropping on the floor is swept and cleaned. The seed collection should be very promptly attended to as they are likely to be eaten away by rats and rodents.

Storage of Seed and Viability

The seed has a very low viability and does not withstand storage for over a month. Generally bamboo seed is stored in dry kerosene tin boxes, after removing all moisture and air from the container. Seed is filled to about nine-tenths of the container and then a lighted candle is introduced in it. After it burns out, the tin container is sealed.

Another method of storage of seed is by keeping it at 4° C in a cold storage. This method allows storage for about a year. However, in a longer period, the germination per cent may decline.

In as much as the germination per cent and the plant per cent decline with storage of any sort, the best way to benefit from large scale seeding in bamboo, is by sowing the seed in nurseries.

Raising of Nurseries

Bamboo can be propagated by planting rhizomes. A live bamboo clump is selected and the rhizomes are dug out along with the shoots, preferably of that year. The shoots are cut to about 15 to 45 cm length. These are called 'offsets'. The offsets are planted. Even the shoot cuttings of about 50 to 100 cm long if planted with one internode in the soil, will sprout. These two methods are however not very successful. It is also seen that offsets or shoots flower at the same time as the mother clumps, and therefore, it is not certain as to how long the plantation thrives.

The best method of raising bamboo is to culture the seedlings in the nursery from seeds.

Fresh seeds are immersed in water for about forty-eight hours. The seed that floats is rejected and the one which settles down is sown.

A primary bed of 12 by 1.5 m is dug up to a depth of 30 cm all the clods are broken and the soil well pulverised. The bed is formed almost level to the ground, after using BHC 10 per cent at about 0.5 kg per bed. Treated seeds as above, are sown with a light cover of soil. As the seeds are likely to be eaten by squirrels, addition of gamaxine is advisable. The germination takes place in about five to ten days, when watering is continued. After the seedlings attain a height of 15 to 20 cm, they would have developed a small curved rhizome, when it is ready for transplanting in the bags. This operation is called pricking out.

Polythene bags of 22.5 by 12.5 m cm of 150 or 200 gauge are preferred for raising bamboo seedlings. Soil mixture of local earth, red earth and sand in the ratio of 1 : 1: 1, with a small proportion of well decomposed farm yard manure is advisable. The soil mixture should be well sieved and all stones, pebbles and foreign matter should be removed and the bags filled almost to the brim. The bags should be watered a couple of days before the transplanting is to be done.

Seedlings should be taken out from the beds after watering and should immediately be planted firmly in the bags. Care should be taken to see that the seedlings are well packed from all sides and no hollows exist round the rhizomes, otherwise they are likely to rot.

Primary beds are formed in September. Bags are kept ready in October. Sowing is done in September only. The seedlings will be ready for planting in bags by November. The bag plants should be watered daily.

Maintenance in Nursery

Six to nine month seedlings raised in bags are of optimum age for planting out.

In the nursery, the bags are arranged in the form of a bed of 12 by 1.5 m. Seedlings which overgrow and attain more than 0.5 to 1 m height can be clipped off for ease in transport and handling.

The bags should be shifted in the beds every fortnight to prevent the roots piercing the bags and rooting in the nursery itself.

Planting

Bamboos can be planted along field boundaries, along the fence and in the form of a plantation. For planting along the fence and field borders a spacing of 4 m is maintained. In case of plantations, the spacing of 5 by 5 m is sufficient. In an area of 1 ha about 400 plants can be planted.

The area to be planted is first cleared of shrubby and thorny growth and stakes fixed at espacements of 5 by 5 m. About two months before planting, at each stake a pit of 0.3 cu m is dug up. Planting is done preferably on a rainy or cloudy day. The bags are transported to the site a couple of days before planting. The polythene bag plant is held in the left hand and the bag torn with a blade and carefully removed without disturbing the soil pack. The dug up pit is filled back to a depth of about 15 cm and the bag seedling is held in the centre of the pit and soil filled and packed well. After the planting, the pit is provided with a 1 m diameter saucer for storage of water, forming a small mound round the plant.

After-care

After planting is done, the saucer pit should be weeded and soil worked every month or once in two months in the first year. Casualties should be replaced with every weeding and soil working till September.

In the second year, two weedings and one soil working are sufficient. The soil working should preferably be done in January/February before the summer season. The depth of soil working should be 15 to 30 cm.

A better establishment and faster growth of the seedling can be achieved if the seedlings are planted on mounds or on mounds formed in a trench of 1 by 0.3 by 0.3 m along the contour. The mound in this case is formed in the middle one-third portion of the trench and the seedlings are planted on this mound. This method leaves two pockets on either side of the mound that can store rainwater and also provide good loose soil for the plant to establish. This method also reduces the number of weedings and soil workings to be carried out. This technique is called 'Sunken Mound Planting'.

Harvesting

The bamboo seedlings establish in about two years and every year, with the growth of the rhizome, the shoots develop in girth and length. The culms will be of exploitable (felling) size in about seven to ten years, depending on the soil available and the climate.

In any given clump, the number of culms to be retained should not be less than six in addition to culms of that year. Older culms and culms over and above the six to be retained, can be harvested. In forest areas, the bamboo forests are divided into four blocks, each block is felled in consecutive years, thus the area covered and harvested will get rest for about three years. No cutting of bamboo is allowed during the growing reason, that is during the monsoons when new culms are developed. This is to prevent damage to the young shoots.

The felling of bamboo is done at a height of 0.5 to 0.75 m and care should be taken to see that all the branches and cut portions are removed from the clump. The young shoots with six older shoots retained in the clump should be well distributed and spaced. In fact harvesting of bamboo amounts to thinning of the culms in the clumps and is a sort of cleaning operation.

Mounding of Bamboo Clumps

After the clumps are harvested and culms extracted, a soil mound of about 50 cm to 1 m is formed around the clump. This soil mound stimulates the rhizome to produce more culms in the rains. The culms so produced are thicker in girth, have longer internodes, and are developed at the periphery of the clumps, which prevents development of congestion. The technique of mounding the soil at the base of the clump is highly productive. The number of recruits is increased from 80 to 100 per cent in good and sandy loam soils.

Utility

Green bamboo is used for basket weaving and mat making, etc. Bamboo is an important produce and is rightly called 'Poorman's Timber'. It can be used wherever timber is used as in cradles, hutments, toys, art pieces and furniture.

Bamboo has long fibres and they give a homogeneous pulp. It is, therefore, a very important raw material in paper and rayon manufacture. The bulk of dry bamboo is supplied to paper mills in the country. The bamboos are supplied to these mills at a royalty of Rs. 350 to 400 a tonne at the factory site. Felling and transport is borne by the mills.

The forests are slowly getting exhausted of this important raw material. To augment the supply, large scale bamboo plantations are being raised by the Forest Departments and the mills also are encouraged to raise their own plantations.

Market Trend

A large population of *Buruds* (Basket makers) depend on bamboo as raw material for their cottage industries. They have also formed societies for assuring themselves a sustained supply at reasonable rates. Each bamboo is sold at Rs. 2 to 2.50, whereas the big bamboo at Rs. 4 to 5. There is no likelihood of any decrease in the demand for bamboo.

Economics

In an area of 1 ha about 400 clumps can be raised and the cost of raising bamboo plantations works out to about Rs. 300 per ha including nursery costs and maintenance.

In about the eighth year harvesting can commence and each clump is expected to yield a minimum of five bamboos, that is in 1 ha we can expect about 2,000 bamboos. Excluding the cost of felling and transport, a net profit of over Rs. 2,000 per ha is possible.

EUCALYPTUS

Eucalyptus is said to have been introduced in India during Tippu Sultan's regime, between 1782 and 1790.

They were introduced in the Nilgiri Hills by Captain Dunn in 1832. The oil yielding Eucalyptus globulous, was introduced by Captain Cotton in 1943.

Regular plantations of eucalyptus were started very early in 1856 itself.

There are over 600 species of eucalyptus in Australia, which is its native ground. And there are species suitable for all climates and altitudes, soils and rainfall.

A species commonly popular is Eucalyptus hybrid which can be grown from sea level to 2,200 m elevation, in tropical to warm temperate climates, with rainfall ranging from 400-4,000 mm and on a wide variety of soils.

Genetic Status of Eucalyptus Hybrid

It appears that a number of eucalyptus varieties were introduced on the Nandi Hills in Karnataka, including several species which were natural hybrids from Australia. These hybrids were identified in 1955, as possible combinations between Eucalyptus robusta and Eucalyptus tereticornis, Eucalyptus botryoides and Eucalyptus tereticornis, Eucalyptus tereticornis and Eucalyptus camaldulensis. While F_1 hybrids between different eucalyptus species are uniform in appearance, F_2 segregate widely between the characteristics of both original parents. They are insect pollinated.

The eucalyptus flowers during September/October and the seeds are ripe in December/January. The seeds are collected from the fruits when ripe, from the trees themselves. Another method of collection of seed is to tie a cloth or canvas supported by stakes, around the tree, at about 1.5 m height, and the seeds dropping from the dehisced fruits collected. The seed is cleaned of the chaff and other foreign matter and stored in tin containers or cloth bags. The seeds are viable for a long time. The seeds are very small and there are over 20,000 to 30,000 in an ounce.

The seeds are sown in a primary bed. The beds of 1.5 sq m are dug to a depth of about 0.3 m and all the stones, pebbles are removed. A soil mixture of fine sand, red earth and farm yard manure in the ratio of 1: 1: 1 is prepared and the bed formed is levelled with the ground. The seeds cleaned and dried is mixed with red soil and spread on the bed. A light shade is initially provided to the beds and watered with a fine rose can. The seeds germinate in about seven to ten days and seedlings attain 12 to 15 cm height in about a month when they are ready for transplanting.

The seedlings are transplanted in polythene bags of 22.5 by 12.5 cm of 150 to 200 gauge. A soil mixture as in the primary beds is prepared and the bags are filled. The seedlings are transplanted in the bags which are watered before for a couple of days. A hole is made with a stick and the seedling put in it and pressed from all sides and well packed. The bags should be filled to the brim and should be uniform without hollows or kinks. The bags are then placed in partial shade. Before transplanting, if the seedlings are sprayed with a light solution of magnesium carbonate, the establishment in bags will be better. The bags should be watered daily and shifted every fortnight to prevent the seedlings from striking roots in the nursery itself. There need be no shade of any kind once the seedlings establish themselves in the bags.

The primary beds are formed in September/October, and the seedlings transplanted in the bags in November/December. A six to nine month old seedling in the bags give good results in the plantation.

In high rainfall areas, the seedlings raised in primary beds are transplanted (pricked out) to a standard bed of 12 by 1.5 m and raised to a height of 22.5 to 30 cm with a well sieved soil mixture. The seedlings from these beds are planted out (naked).

The area to be planted is staked at 2 or 1.5 sq m and at each stake a pit of 0.3 cu m is dug up about a month before the monsoon. The plants are transported to the planting site a couple of days before planting. The pits and the soil are sterilised with 10 per cent BHC solution or gamaxine powder and then the planting is done. The polythene bags are removed and the plant with its soil in the bag placed in the pit and filled back.

The plants should be kept weeded and soil worked at least three times in the first year and twice in the second year. With every operation the casualties should be replaced.

Present Trend in Raising Eucalyptus Plantations

Eucalyptus plantations are now being raised as a commercial crop, with high inputs of fertilisers, irrigation and ploughing. The trend in some countries is to develop high density plantations, that is, to plant the seedlings at close spacing of 30 cm to 1 m, irrigate the crop and harvest in a small period of three to four years. This nature of planting is being practiced by industries for their raw material needs.

The ideal conditions of raising Eucalyptus for small timber and pulpwood without provision of irrigation and fertiliser, is to plough the area before planting. Plant the seedlings at 3 m by 1.5 m spacing. The wider space is provided to enable ploughings subsequent to planting. This system costs about Rs. 10,000 per ha and at the end of seven years a return of about Rs. 25,000 is possible.

Eucalyptus plants raised in high rainfall zones are susceptible to fungal attacks. Corticium salmonicolour called the pink disease is serious in Kerala. Other fungi are Ganoderma lucidum, Cylindrocladium quinqueseptatum. In some areas top drying is also noticed which is attributed to chlorosis due to lime induced iron deficiency.

In some of the plantations in the dry tracts of Khammam and Adilabad in Andhra Pradesh, a cracking of the bark generally on the western side of the trees is noticed. At these cracks a ooze which later becomes viscous, is exuded. The phenomenon is called 'gummosis'. At the point where the ooze manifests the trunk dries and a wound develops, which with slight high velocity wind, cracks and the trees fall. The suggested solution for this is to plant the trees at closer espacement and provide shelter from the westerly sun. This is a problem yet to be fully studied.

At the seedling stage, in the plantation a grub yet to be identified, damages the roots. After this damage termites are active. For this reason the pits are sterilised before planting.

Eucalyptus wood is a good raw material for pulp and poles are used for pit props, *pandals* and as fuel. Therefore, they can be harvested between eight and ten years as large sizes are not needed for these purposes. The wood is transported for pulping, within a week of the felling, otherwise it develops a bluish colour hard to bleach. Large scale plantations of this species are being raised to provide raw material for pulping. The pulp is also fit to make rayon.

Nilgiri oil is an extract from the leaves of Eucalyptus citrodora and Eucalyptus globules grown at high altitudes. All the other eucalyptus do have the principle oil, but extraction is uneconomical.

The paper mills and rayon factories are prepared to pay Rs. 400 to 500 a tonne of this wood. Its market, however, is yet to stabilise.

The tree can be grown for its aesthetic value in gardens and along roads, where it should be in the second row. It is one of the best species to be grown on farm lands as its shade is not heavy. Nesting birds are few and far between.

TEAK

Tectona grandis (Family: Verbenaceae), Hindi: *Saguan*

Teak is called the king of the timbers. Its weight is roughly 50 pounds to a cubic foot and is not damaged by insects and termites, when all other timbers are susceptible to damage by one insect or the other.

In moist deciduous forests and in some evergreen types, it grows to a gigantic size. The teak grown in heavier rainfall zones has almost uniform and light colour. The teak from deciduous and dry deciduous forests give good colour patterns due to lignin of various hues in the growth rings. The dry teak has pronounced growth rings (annual rings), which when sawn and arranged give beautiful designs. Dry teak is, therefore, preferred for furniture, plywood veneers and door shutters, etc. It is very strong and can withstand stress and strain in all directions. Next to rose wood of exportable quality, teak is the costliest wood in our country.

Teak grows well in deep sandy loam soils overlying limestone. It needs a well drained soil and does not withstand waterlogging or salinity. It is gregarious and is resistant to fire and grazing in the forest.

Teak plantations have been raised for more than 120 years in our country.

Teak flowers in July/August and sometimes at the end of the monsoons. The flowers are found on the apex of the branches. Fruits appear in November/January and are ripe for collection in February/March.

The seed is thick with a hard endocarp, about 1 to 1.5 cm in diameter. The seed can be stored for about one year or even more. The germination per cent declines with storage for more than one and a half years. It can withstand storage due to its being encased in a thick endocarp which is corky and needs a great amount of power to break. There are one to four seeds in each fruit (ovules) ; sometimes all the four may be present or one or more may be absent leaving the ovule hollow. There are about 1,500 seeds in 1 kg. The collection is done by hand from below the good mother trees.

Teak can be raised by planting stumps in a crow bar hole. It is one of the easiest species to raise in a well drained sandy loam soil and on slopy ground with deep soil.

The seeds collected in February/March, are cleaned and graded by sieving. The large and medium size seeds are only used in the nursery and the damaged ones and small seeds are rejected. The seed needs to be treated to soften the hard cover. This is called pretreatment. It consists of the following steps:

i) The graded clean seed is spread on a hard sloping ground or on cement floor to a thickness of about 15 to 30 cm.

ii) A thin layer of hay is spread on the seed to provide humidity.

iii) The spread seed is watered twice in the day, morning and evening. Thus the seed is alternatively wetted and dried.

iv) The above watering and drying is continued for about a fortnight till the seed develops a white radicle, when it is ripe for sowing.

Sowing of seed is done in a standard bed of 12 by 1.5 m. The nursery site is divided to form 12 by 1.5 m plots at 0.5 m intervals. The staked bed site is dug up to a depth of 30 cm. The soil is weathered for a month. The dug up bed and the earth are sterilised by burning heaped debris over them, this will destroy any insects or eggs laid in the soil. The cavity of the bed is then dusted with BHC or gamaxine powder and the bed formed by 10 cm layers ; on every such layer BHC or gamaxine is dusted. Sand is added to the bed if the soil has clay to improve the texture and drainage. Care is taken to see that all clods are broken and pulverised. The bed is raised above the ground to a height of 22.5 to 30 cm. If the soil is too sandy, the beds are enclosed with curbing by using bamboo splits or brushwood. No farm yard manure should be added nor cattle refuse allowed to lie in the nursery site, as these breed grubs which spread like an epidemic and destroy the seedlings.

The beds are sown with well treated seed in April, about 8 kg per bed. After sowing they are covered with a light cover of hay and watered daily. When germination sets in, the hay cover is removed. The beds are watered daily till the rainy season sets in and watering is also done when rains cease or there is a long gap in rains.

The seedlings attain stumpable size, that is a thickness of a pencil, at the collar, by June of the next year. The beds are kept clean of all weed growth.

The beds are maintained for two years as even after taking out the seedlings in the first year, some dormant seeds germinate and yield stock in the second year also. If faster growth of the seedlings is noticed during the first year, it is likely that the seedlings may overgrow in thickness beyond that of optimum thickness and this will not be useful for planting. To prevent this, the overgrown seedlings in the beds should be cut back to the collar. This operation will also help in getting better stock from each bed.

In assured rainfall areas what are called dry beds are raised. Here the seed without treatment is sown on beds in March and these get softened in the hot summer and with a good rain they germinate. The beds are weeded frequently to maintain the stock. The watering is done only by monsoon rains and they sometimes take two years to give the plantable stumps.

A record of all the operations with dates and the amount spent and observations are recorded in a book called the Nursery Journal.

Planting: The area selected for planting is cleared of all growth, weeds and shrubs and trees. In the forests, the area to be planted is selected a year in advance and all the standing growth is sold or felled and disposed of. The lops and tops and debris are evenly spread in the area and burnt to give a uniform scorching to the soil. This operation improves the texture of the soil and kills the weed growth. As teak does not stand any competition with weeds or grasses or other growth, it is essential that a good burn is given to the site. The burning of debris is completed by the end of May.

The area to be planted is staked with stakes of 0.5 m. Generally split bamboo is used. The espacement is 2 by 2 m.

The seedlings are dug out from the nursery when the rains commence, the shoots are cut up to the collar, the root (tap) is trimmed and all the hair roots, etc., removed and a stump of 22.5 cm is prepared. Any seedling with a thin stump or below 1 cm diameter is rejected or replanted in the nursery, to develop. The stumps are planted in a hole driven near the planted stake, about 10 cm away from it, and in one direction for all stakes. The stump is held flush to the ground and with the crow bar all the sides are pressed to fix the stump. Care should be taken to see that the stump is not buried in the soil, nor is it protruding above the ground level otherwise the shoots will have to struggle to come out of the ground. No hollow space should also be allowed round the stump as this will lead to collection of moisture and the stumps will rot.

The stumps planted sprout within a week. After about 10 to 15 days, the sprouts are singled, that is one sprout is retained for each stump. This operation is called singling and helps in better height growth.

The plantations are given three weedings along with soil working. There are two methods of weeding:

(i) Strip weeding and (ii) Circular weeding. In strip weeding a belt of 1 m is scraped along the planting line, the second weeding will be in a direction perpendicular to the first weeding and the third weeding is done along the strip of the first weeding. The weedings are done in July/August, October/November and December/January. A soil working is also done to each plant in February.

In circular weeding, the weeding is confined to a circle of about 1.5 m radius around the plant. The strip weedings are preferred in moist areas and high rainfall zones, where weed growth is heavy. Circular weeding is done in dry zones and with low weed growth. Along with these operations any miscellaneous growth from stumps and stools, climbers, etc., are cut back which is called coppice cutting.

The area planted is fire protected by scraping a 3 m wide belt round the plantation, and the inspection paths are also scraped. This prevents any ground fire entering the area from outside and even if any fire comes in, it will be localised by the inspection paths. In forest areas, particularly in dry deciduous types, ground fires in summer are common, which burn the leaf litter.

Any plants damaged due to cattle, fire or while operations are in progress, are cut back in the pre-monsoons of the next year.

In the second year of the planting, the same operations are repeated. In the third year, two weedings and one soil working is done and in the fourth year one weeding and one soil working. In the fifth year any double leaders or coppice and other growth are cut back and branches pruned.

In 1 ha with a 2 by 2 m espacement, there will be about 2,500 plants. In the seventh or eighth year, 50 per cent of these plants are taken out by felling alternate plants. This operation is called mechanical thinning. Again a second mechanical thinning is done by felling 50 per cent of the poles in the fifteenth or sixteenth years. The last thinning is carried out in the twenty fifth year, where all the good straight trees are retained and all the stunted, damaged or malformed poles are removed. This is a silvicultural thinning, which has to be done with care.

These operations give intermediate yield of poles which are marketed.

A teak plantation attains the size of timber for planks and sawn sizes in about 70 to 80 years.

The cost of raising the plantation up to the fifth year, works out to about Rs. 1,000 per ha.

Teak timber is used extensively for construction purposes. The veeners from good sized teak logs are used for uppers plays of a plywood for doors and windows. It is the only species extensively used for furniture. Seasoned teak lasts for centuries, hence the high demand. The market for teak is on the rise, as good teak forests are getting exhausted fast. Teak poles are sold at Rs. 40 to 60 each and logs of about 20 cm (8 inch diameter), are sold on volume basis at Rs. 2,500 to Rs. 3,500 per cu m. Teak logs of above 60 cm diameter are sold at Rs. 5,000 to 6,000 per cu m.

RED SANDERS

Leguminosae (Papilionaceae) (*Pterocarpus santalinus*)

This species is found in the Sheshachalam and Veligonda Hills of the Cuddapah, Chittoor and Nellore districts of Andhra Pradesh. The species is also found sparsely in the Chingleput and North Arcot districts of Tamil Nadu. It is not found naturally in any other part of the world.

The heart wood of this species is dark red in colour and is said to be of high medicinal value. Its powder and dust are used as fish preservative and its distil is used for medicines, particularly for heart diseases and as a purifier of blood. Certain trees in red sanders, develop wavy grain, which is highly priced and exported. This wavy grained wood is called 'quality' wood and is said to be used in Japan for making a musical instrument called 'samsien' given to every bride by her parents. Both 'quality' and non-quality wood is exported to Japan.

Toys and bowls made of red sanders last long. Red sanders is stated to absorb radiation in a nuclear plant and can be put to use in atomic reactors. It also absorbs sound to a great degree.

It is believed that the staff which Moses threw into rock waters to purify the water in the Sinai Peninsula was of red sanders.

Red sanders flowers in November/December and the fruits, thin with a papery cover, develop in February/March. Seeds are collected manually from below the mother trees.

The nursery techniques and planting techniques are the same as for teak, except that seeds do not require any pre-treatment. In a bed, 12 by 1.5 m, half a rice gunny bag of seeds are sown. In case of red sanders only circular weedings are advocated. The seedlings in severe drought die, but sprout again in the rains. Deep soil working is essential for the seedlings. Red sander stumps planted on mounds have given good results.

The plants are harvested when they develop heart wood in about 25 to 30 years. As even small pieces of this wood are used for several purposes, the optimum size for harvesting the trees is when they reach a girth of 60 to 80 cm.

The chips can be distilled to give the 'Santaline' an alkaloid for medicines. Poles are used for posts and wood pieces for toys, etc. Tirupati toys made of this wood are very popular. Wooden containers of red sanders are used for storing salts and pickles, etc.

The non-quality wood is sold at Rs. 1,500 to 2,000 a tonne and the quality wood between Rs. 5,000 to 50,000 a tonne, depending on the depth of the wavy grain.

A research scheme to study the causes for development of wavy grain in the wood and grading of wood is possible.

CASUARIANA

Casuariana equisitifolia (Family: Casuarianaceae) Hindi: *Sarvoo*

This species is indigenous to the coastal areas of the Bay of Bengal. It was also introduced in the inland areas of Karnataka and Andhra Pradesh, where its growth is not as fast as on the sea coast.

This is a tall straight stemmed evergreen tree, the ends of branches thickly set with numerous long slender leaves which are mostly deciduous and are modified leaves.

The fruits are achenes. The flowering occurs in December/January and the fruits are developed by end of February and are ripe for collection of seed in March. The seed are very small, about 18,000 to 20,000 in an ounce.

Collection of Seed

The achenes are collected and dried on a clean flat surface and are thrushed to drop the seed. The seeds are collected by winnowing the thrushed achenes. Seeds are viable for about a year and can be stored in polythene bags or tin containers. Germination occurs within a week and the germination percentage is about 20 per cent.

Nursery

A *casuariana* nursery is formed in a standard bed of 12.5 by 1.5 m with a slightly heavy admixture of sand. Seedlings are transplanted in bags when they attain 15 to 22 cm. Even older seedlings and tall seedlings withstand transplanting. In the coastal areas casuariana naked seedlings are transplanted in the planting site itself. For better establishment, the seedlings raised in polythene bags should be used.

The seedlings either in bags or in beds are maintained in the nursery for about six to nine months.

Planting

The area selected for planting is staked at a 2 by 2 m espacement. Espacements of 1 by 1 m and 1.5 by 1.5 m are also common in the coastal belts.

Casuariana is usually planted out at stake with the naked roots. At each stake a pit of 0.3 cu m is dug and the seedlings planted. In Orissa and Gujarat, the seedlings raised in polythene bags or containers are planted in the pits.

It is always watered in the first year and where the water table is deep, watering is done for one or even two years more during the hot weather of May and June.

The planting is done in July when the plants are 40 to 50 cm and watering is done in the following January to July twice a week. About five litres (one gallon) of water per plant is used.

The cost of raising the plantation works out to about Rs. 400 per ha.

After-care

The plants have to be soil worked and weeded every month and casualties replaced till September. Deep soil working is very important for casuariana plantations to prevent evaporation of sub-soil moisture.

Harvesting

The plantations attain good height and girth in the coastal areas in about six to eight years, when stems are about 45 to 65 cm girth at breast height.

In the interiors and in the plateaus the optimum dimension is attained between eight and ten years.

Harvesting can be done at any time after the fifth year, depending on the demand. If bigger sizes are required a longer period is allowed for growth.

The trees are easy to fell with a saw, and after felling the logs and tops and branches are removed by saw only and the poles up to 15 cm girth at the top are transported. If the disposal is for fuel the trees are cut into 1 m billets by saw. In the coastal areas and nearer big cities, even the needles (leaves), small branches and the roots are dug out for sale as fuel.

Utility: *Casuariana* can be trained and trimmed to form any sort of hedge or border and it can be made to conform to any required shape.

Casuariana poles can be employed for scaffolds in building constructions and for marriage *pandals*, etc.

It provides one of the best fuels with very high calorific value. The fuel billets are easy to handle. In large tracts of sandy waste along the coast farmers grow casuariana as a cash crop.

One ha of casuariana plantation can give about 25 to 30 tonnes in its sixth to eighth year. The fuel is sold at Rs. 400 to

500 a tonne. Thus with an investment of about Rs. 400 for raising and about Rs. 200 for felling and about Rs. 500 for transport, 1 ha will give roughly Rs. 10,000. One can raise 2,500 to 4,000 plants in 1 ha.

ACACIAS

Leguminosae (Mimosoidae)

There are several species of *acacias*, which are useful for purposes of farm forestry and social forestry. *Acacia arabica* can be grown in swampy and saline soils. All the *Acacias* can be grown in almost all varieties of soils. But they attain good dimensions in well drained sandy loams. The various *Acacia* species of importance and their utility are detailed:

1) *Acacia arabica*: This is called *Babul* in Urdu and Hindi, grown in tank beds, along the farm bunds and also scattered in dry land agriculture. It can withstand submersion in water for some time and tolerates salinity. The wood is used for ploughs, cart axles and also as fuel. It is best grown in black cotton soils where other trees hardly succeed.

The tree when blazed exudes the famous arabic gum used in confectionery and as an adhesive. When grown in agricultural lands, it exercises least effect on the growth of annual crops. The pods are fed to sheep and goats.

2) *Acacia leucophloea*: *Safed Babul* in Urdu and Hindi. This is a very hardy species and can be grown in very dry tracts, commonly found in the southern states of our country. It can be put to the same use as *Acacia arabica*.

3) *Acacia catechu and Acacia sundra*: *Khair* in Urdu or Hindi, grows in the drier tracts of the dry deciduous forests. In the moist belts it attains good dimensions. The wood gives on distillation the famous *cutch and katha* used as a tanning material and along with betel leaf for chewing.

4) *Acacia nilotica*: Commonly found in the dry zones of Punjab and Gujarat. It has all the properties of *Acacia arabica*.

5) *Acacia planifrons*: This is the driest of all the *Acacias*. It is found growing in dry tracts of Rayalaseema in Andhra Pradesh and Karnataka, on shallow eroded soils. A good species for afforestation and to clothe the land.

6) *Acacia auriculiformis*: An introduced species for afforestation. It has no thorns. Good for fuel.

7) *Acacia mollissima*: Along with two other species, which are grouped as wattles, it has been introduced from Africa, in the hills of Ooty. These are high altitude *acacias* and the powder from the bark is used as a tanning material. The product is called wattle powder. Unfortunately its market has dwindled due to synthetic substitutes.

Almost all the *acacias* flower during January/February and the pods remain on the trees for long. The seeds can be collected in April/May, when the pods are greyish-white in colour.

The seeds are hard with a hard endocarp, except for *Acacia catechu* whose seeds are thin with a paper disc. The seeds can be stored for over one year in gunny bags or containers.

As the seeds are hard, to obtain good germination older seed is generally sown. Seeds collected from the droppings of sheep and goats fed on the pods germinate better. The seeds can also be immersed in boiling water before sowing.

The pre-treated seeds can be directly sown where the trees are to be raised. They can also be sown in bags directly or sown or raised in standard beds. The seedlings raised in beds are taken out and transported with a ball of earth to the planting site. Seedlings of six months to one year are used.

In afforestation plots, the treated seeds are sown on mounds or in ploughed furrows, and when germinate the seedlings are singled out.

Acacias are commonly raised in rows in the tank beds, or on farm bunds and in the agricultural fields. Soil working the seedlings at least once a month will give better establishment. It is one of the easiest and cheapest species to raise in the field or nursery.

Harvesting is rarely resorted to before the tree is mature at 30 to 40 years. In fuel plots the trees can be harvested in 10 to 12 years. Although it is not a coppicer when felled the stools give shoots which can be tended for a future crop. In afforestation plots the trees are felled when dead or mature.

For manufacture of *katha*, the Sundra trees are felled when they are above 45 cm at breast height. The trees are chipped and cooked for extract. The scum collecting in the cooking pots is separated and the thick residue is collected, purified and sold as *katha*. The Forest Department gets a royalty of Rs. 15 to 25 per tree.

Almost all the *acacias* are good fuel species, in addition they can be used for ploughs and for hutments. At 10 to 12 years, the fuel yield is about 0.25 tonne per tree and is valued at Rs. 200 to 300.

Nursery Practices and Raising of Miscellaneous Species

1) *Neem*: *Azadirechta indica* (Meliaceae) flowers in March and fruits in April/May is collected manually and the pulp washed. Seed has low viability. Sown directly in afforestation plots. Seeds sown in bags and seedlings of three to four months planted as avenue. Seeds give neem oil and neem cake for fertilisation of grape gardens, etc.

2) *Drumstick*: *Moringa pterygosperma* (Moringaceae). The pods can be used for curries. The wood is soft, corky and perishable. It is raised by planting branch cuttings. Seeds from pods when dry, that is in May/June can be sown in bags and seedlings transplanted. The pods from wild trees are bitter to taste, whereas those cultivated are edible.

3) *Glyricidia maculata*: Leguminosae. An introduced species. Very good fodder for cattle and for green manure. Can be cultivated from cuttings of branches or seeds sown in bags and watered for a month or two for planting.

4) *Sesbania*: There are two species. *Sesbania aegyptica* and *grandiflora* (leguminosae, papilionaceae). The poles can be used for thatching. Flowers are used for curries. Generallycultivated to support betel vines and sugar cane. They are fast grown. Raised by direct sowing of seeds or in bags and transplanted.

5) *Sapindus emarginatus:* Sapindaceae: Hindi: *Rita*. Flowers in December/January and fruits in February/March. Fruits are used for washing and as a substitute for soap. The seeds are large, of the size of a small marble and can be stored for over a year. Raised by direct sowing in bags and transplanted after six to nine months. Planted for the soapnut and fuel. A good species for farm forestry.

6) *Agave*: *Agave americana*, *Agave sisalana*. Both the species are introduced. Commonly used as a live hedge for fields. The fibre from leaves of both the species is used for fishing nets. Sisal fibre is in high demand and its ropes are used for marine cor-

dage. Can be raised by planting bulbils in the nursery bed. When they develop pairs of leaves, they are transplanted to site. Leaves can be harvested from fifth year.

7) *Mulberry*, *Morus alba:* Urticaceae. Cultivated for fruit, a very fast growing species. Can be cultivated by sowing seed directly. Flowers in March to June and fruits June to August. Silk worms are reared on its leaves.

8) *Pongamia glabra*: *Leguminosae*. Telugu: *Kanuga*, Hindi and Urdu: *Karanj*. Can be raised by direct sowing of seeds in bags. Flowers in November/December and fruits in February/March. Cuttings also can be planted. The wood is used as fuel. Seeds give oil for lamps and medicine. The leaf is a good fodder and green manure.

9) *Zyzyphus jujuba*: Rhamnaceae, Urdu: *Ber*, Telugu: *Gangaregu*. Flowers in November/December and fruits from January to March. It is one of the fruit plants for Tussar silk worm. Branches are used for fencing the fields.

The seedlings can be raised by direct sowing in bags or *in situ*.

Zyzyphus jujuba buds have been grafted on other *zyzyphus* plants successfully.

10) *Murraya koenigii*: Rutaceae, (curry leaves plant), *Kat nim* in Hindi. Flowers in March/April and fruits in May/June. Very difficult to raise. The seeds are short lived. Direct sowing of seeds is the best method. Mainly raised for the leaves.

11) *Cenchrus ciliaris*: An Australian grass, can be raised by direct sowing of seed or by transplanting slips, in ploughed areas.

APPENDIX

HINDI AND VERNACULAR EQUIVALENTS OF THE TREE SPECIES RECOMMENDED FOR FARM FORESTRY

Botanical Name	Hindi Equivalent
1. *Acacia arabica*	बबूल
2. *Acacia catechu*	खैर
3. *Acacia concianna*	अल्ला
4. *Albizzia lebbek*	सिरस
5. *Albizzia procera*	सफेद सिरस
6. *Alstonia scholaris*	
7. *Adina cordifolia*	हलदु
8. *Ailanthus excelsa*	मारुक
9. *Artocarpus hirsuta*	फनस
10. *Azadirechta indica*	नाम
11. *Anacardium occidentale*	काजू
12. *Acrocarpus fraxinifolius*	कटहल
13. *Bambusa arundinacea*	बांस बंग
14. *Bauhinia variegata*	कचनार
15. *Bombax malabaricum*	सीमल
16. *Butea monosperma*	पलास
17. *Cassia siamea*	पहाडि नडवड
18. *Cassia renigera*	
19. *Cassia javanica*	जावा की रानि
20. *Casuariana equisitifolia*	सरू
21. *Cedrela toona*	तून्
22. *Dalbergia sissoo*	सीसम
23. *Dalbergia latifolia*	शीशम
24. *Dendrocalamus strictus*	बांस
25. *Delonix regia*	गुलमोहर
26. *Dudonea viscosa*	जंगली अनार
27. *Duranta plumeria*	
28. *Emblica officinalis*	आंवला

29.	*Enterolobium saman*	
30.	*Eucalyptus* species	नीलगिरि
31.	*Eugenia jambolana*	जामुन
32.	*Feronia elephantum*	कवीट
33.	*Ficus* species	पीपल या बड्
34.	*Glyricidia maculata*	
35.	*Gmelina arborea*	गुमर टेक
36.	*Grevillia robusta*	सिल्क ओक
37.	*Hardwickia binata*	अंजन
38.	*Holoptelea integrifolia*	नाँवली
39.	*Jacaranda mimosaefolia*	
40.	*Lannea grandis*	मागीर
41.	*Lagerstroemia flosreginae*	लेंडिया
42.	*Mangifera indica*	आम
43.	*Melia azadirechta*	गौडनीम मार्गोसा
44.	*Moringa pterygosperma*	सुजना
45.	*Madhuca latifolia*	महुवा
46.	*Murraya* spp.	कटनीम
47.	*Ougenia dalbergioides*	सदन
48.	*Peltophorum ferrugineum*	
49.	*Prosopis juliflora*	जंगली झन्द
50.	*Pongamia glabra*	करंज
51.	*Polyalthia* spp.	अशोक
52.	*Pithecolobium dulce*	विलायती इमली
53.	*Santalum album*	चंदन
54.	*Sapindus emarginatus*	रीटा
55.	*Sesbania grandiflora*	बाका
56.	*Sesbania aegyptica*	सिंवि
57.	*Spondias mangifera*	अंबारा
58.	*Tamarindus Indica*	इमली
59.	*Tectona grandis*	सागवान
60.	*Terminalia* spp.	ओत, अर्जुन
61.	*Thespesia populnea*	रान पीपल
62.	*Tecoma* species	
63.	*Vitex negundo*	सिंभालू
64.	*Wrightia tinctoria*	काला इंदरजाव
65.	*Zyzyphus jujuba*	बेर

SUGGESTED SCHEMES FOR RAISING AVENUES FOR AESTHETIC VALUE

					Month of Flowering
Scheme No. I	*Bauhinia variegata* (Purple mauve variety)	*B. variegata* (White variety)	*B. kurjii* (Light magneta variety)	*B. variegata* (Light pink variety)	February/March
Scheme No. II	*Spathodea nilotica* (Orange crimson)	*Erythrina indica* (Scarlet red)	*Spathodea nilotica* (Orange crimson)		March/April
Scheme No. III	*Jacoranda mimosaefolia* (Blue)	*Grevillia robusta* (Yellow)	*Jacoranda mimosaefolia* (Blue)		April
Scheme No. IV	*Amaltas* (Yellow)	*Gulmohar* (Scarlet orange)	*Amaltas* (Yellow)		May
Scheme No. V	*Cassia nudosa* (Pink)	*Cassia marginata* (Pinkish red)	*Cassia nudosa* (Pink)		May/June
Scheme No. VI	*Peltophorum ferrugenium* (Golden yellow)	*Colvillea racemosa* (Orange red)	*Peltophorum ferrugenium* (Golden yellow)		October
Scheme No. VII	*Acacia auriculiformis* (Yellow)	*Thespesia populnea* (Red purple)	*Acacia auriculiformis* (Yellow)		October

Reference: *Flowering Plants of India*, M.S. Randhawa.

INTRODUCTION TO SOCIAL FORESTRY

SECOND EDITION

M. Sitaram Rao

This book introduces the subject of Forestry and various practices of Social Forestry. This subject has gained considerable momentum recently due to large-scale degradation of the tree cover in the country. Waste Land Development has gained high importance for all. The book details several measures to raise forests and tree cover in various locations.

The book introduces various techniques to raise forests and will be invaluable to all those interested in preservation of equilibrium in the environment and for those who are interested in forests and forestry.

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